# Economic Ecology Benefits Research of Combined Circular Agriculture

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***Abstract:*** *Realizing the thrift and cyclic utilization of natural resources, improving agricultural economic benefit and ecological efficiency are the basic requirements of combined circular agriculture, and also the inevitable directions of Chinese agricultural development. This paper based on farmer economic theory, take the farmer fertilizer inputs of the three provinces Shandong, Shanxi, Hubei as examples, through establishing econometric models, through knowing the farmer reduction inputs and its influence factors in combined circular agriculture, to make study to the economic ecology benefits research of combined circular agriculture. The research result shows only under "incremental utilization" and "decremental utilization" these two choices, most farmers tend to the decremental utilization of fertilizer"; in addition, the gender, family agricultural acreage of agricultural production decision makers, the cognition degree, government technical support degree of farmers to combined circular agriculture all have obviously impact on fertilizer application behaviors. To further stimulate farmers reduce using means of production during productive process, it needs to promote paying attention to the guidance of agricultural productive large-scale growers and women, improve the cognition degree of farmers to combined circular agriculture, reinforce government technical support degree, and improve economic ecology benefits of combined circular agriculture.*

***Keywords:*** *Farming, Combined circular agriculture, Reduction, Binary logistic regression model.*

## Introduction

Currently in China's agricultural production, the phenomena of pesticides and fertilizers input too much is ubiquitous. Superfluous production goods input not only increases agriculture production cost, but also causes heavy burden to ecological environment, which influences the sustainable development of agriculture. Therefore, while preserving agricultural growth, it is necessary to realize the waste and cyclic utilization of agricultural natural resources. Keeping the largest developments of the agroecological system functioning promotes the optimization of agricultural economic activities, which has become a burning question in current agricultural development, while addressing the basic requirements of developing combined circular agriculture. Currently the researches about combined circular agricultures mainly concentration on following four aspects:

- researches about combined agricultural concept, connotation and model [2, 6];
- researches about each province's combined circular agricultural development situation and policy suggestion [11, 14];
- evaluation researches about combined circular agricultural development [9];
- other field studies related to combined circular agricultural development [3, 10].

## Theoretical framework

### *Study object and method*

Developing combined circular agriculture, realizing the changes of following three aspects: The first one is transforming from production function to coordinated development of both ecological and social. Developing circular agriculture should change the ideas of current heavy production light environment, heavy economy light ecological, heavy quantity light quality, which not only focuses on quantity to meet the supply, but also focuses on quality to assure safety; which not only focuses on the improvement of ecological benefits, but also focuses on ecological environment construction [12]. Second is the transformation from one-way resource utilization to circulation pattern. Traditional agricultural production's activity performance is the one-process linear growth model of "resource-product-garbage", the more of output, the more resources consumes, and the more discharge of garbage, the more serious of the damage to ecology and pollution to environment. Circular agriculture with the principal line of extension of industrial chain, promote one-process agricultural increase model transforms to "resource-product-renewable resource" cyclic aggregative model. Third is transforming from extensive and high consumption type to resources-conservation and efficiency type. Specific progress is showed as Fig. 1.

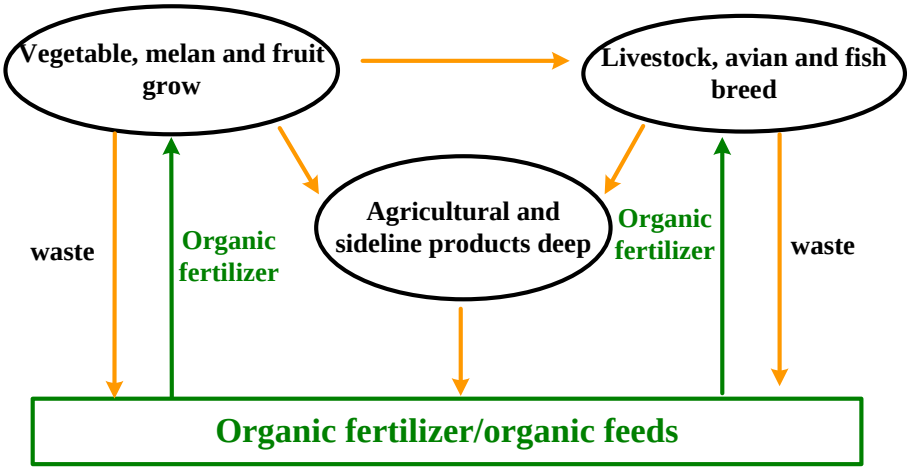


Fig. 1 Combined circular agriculture

Combined circular agricultural reduction principle means under the situation of guaranteeing the material needs of social economic system, reduce the asking natural resources, reduce agricultural input costing, thus reduce the pressure of human economic activities to natural ecological system and improve agricultural productive efficiency. Specifically, that is to realize "nine saves and one reduce", namely save land, water, species, fertilizer, medicine, electricity, oil, grain, firewood, reduce human [7].

To research farmers' reduction input behaviors should utilize econometric model to make estimation to the effect degree and its significance of all kinds of influence factors. Generally, the factors influence farmers reduction input behaviors mainly has three aspects:

- agricultural productive decision markers personal feature (A);
- household-based productive status (B);
- external influencing factor (C).

Measurement model can be expressed in the following functional form:

$$P_i = f(A_i + B_i + C_i) + \varepsilon_i, \quad (1)$$

where $P_i$ in the formula tend to be "incremental application" or "decremental application" fertilizer on stream; $\varepsilon_i$ is random disturbance term, which reflected the unobserved other influencing factors.

This paper uses binary logistic regression to make quantitative analysis, the concrete form of regression model is:

$$Ln\left(\frac{Prob_i}{1-Prob_i}\right) = \alpha + \sum_{k=1}^{n} \beta_k x_{ki}, \quad (2)$$

where $Prob_i$ means the probability of happening, $\alpha$ is a constant term, $\beta_k$ is a regression coefficient, $x_{kt}$ is an explaining variable.

### *Variable declaration and theoretical assumption*

On the basis of the field investigations to three provinces of Shanxi, Shandong and Hubei, this paper comprehensive analyzes the behaviors of farmers in combined circular agriculture, extracts the major factors which influences farmers reduction input behaviors. Specifically are:

- Farmers' productive decision makers personal features, including the sex, age, literacy and concurrent business situation of farmer productive decision makers, and cognition degree of combined circular agriculture, whether use scientific fertilization technology.
- Family producing and operating status, includes family agricultural acreage (sum of own lands and rented lands), agricultural land classification, last year's family income (net income);
- External influencing factors, includes local traffic condition, local communication condition, government technology support force. The evaluations of each independent variable and the influencing direction of farmer reduction input behaviors are showed in Table 1.

## Data sources and descriptive analysis

### *Data sources*

The data of this paper derives from the field research "Combined circular agricultural development research in the integration of ecological industrial chain and ecological value chain" of National social science fund project. The research places are Jingzhou City, Jingmen City, Suizhou City of Hunan Province, Jining City, Laiwu City, Heze City, Weifang City of Shandong Province, and Datong City of Shanxi Province. Choosing the above three provinces' farmers as the object of study mainly based on following considerations: Shandong is the advanced province in agriculture and the whole development level of agriculture is superior. Hubei is our major agricultural province, which is one of the important granaries in our country – the development level of agriculture is acceptable. Shanxi province is located in poor area of loess plateau. The agricultural ecological environment of Shanxi is very weak. The development level of agriculture is inferior. The agriculture of the sample provinces basically represents the three levels of Chinese agricultural development (good, moderate, poor), and the choice of the above provinces as typical study fields was needed to analyze whether the behaviors of Chinese farmers in combined circular agriculture has certain

representativeness. During study process, totally granted 400 questionnaires to three provinces' farmers, takes back 375 valid questionnaires, the effective rate reaches to 93.75%. Research content involves infrastructure construction and environmental conditions of sample point [1], respondents' features, respondents' family business circumstance and views of farmers to combined circular agriculture as it is shown in Table 1.

Table 1. Variable evaluation and influencing direction

| Variable | Evaluation | Influencing direction |
|---|---|---|
| The farmers fertilizer behavior ($y$) | 0 = Tends to decremental utilization; 1 = Tends to incremental utilization | |
| Local traffic condition ($x_1$) | 1 = Very good; 2 = Good; 3 = Average; 4 = Poor; 5 = Very poor | + |
| Local communication condition ($x_2$) | 1 = Very good; 2 = Good; 3 = Average; 4 = Poor; 5 = Very poor | + |
| Policy-makers' gender ($x_3$) | 0 = Female; 1 = Male | Uncertain |
| Policy-makers' age ($x_4$) | Years of age | Uncertain |
| Policy-makers' literacy ($x_5$) | 1 = Illiterate and semi-illiterate; 2 = Primary school; 3 = Middle school; 4 = High school or Vocational school; 5 = Junior college or above | – |
| Policy-makers' multiple occupation situation ($x_6$) | 0 = Single occupation; 1 = Multiple occupations | Uncertain |
| Family agricultural acreage ($x_7$) | $hm^2$ | Uncertain |
| Agricultural degree ($x_8$) | 1 = Excellent; 2 = Moderate; 3 = Inferior | + |
| Last years' family income ($x_9$) | Yuan (RMB) | Uncertain |
| Cognition degree to combined circular agriculture ($x_{10}$) | 0 = Never heard of; 1 = Have heard of | – |
| Technical support degree of government ($x_{11}$) | 1 = Very large; 2 = Large; 3 = General; 4 = Small; 5 = Very small | + |
| Whether have learned scientific fertilization technology ($x_{12}$) | 0 = Never have learned; 1 = Have learned | – |

## *Descriptive analysis*

Before making regression analysis to models, it is necessary to make descriptive analysis to variables so as to grasp the statistical property of variables on the whole (Table 2).

The average value of $y$ is 0.3520, which is more closer to 0. It means majority of farmers in survey area tends to incremental fertilizer utilization. The average value of $x_1$ is 2.0533. The traffic condition in survey area is between preferably and general. The average value of $x_2$ is 2.0533. The communication condition in survey area is also between preferably and general and is tend to preferably. The average value of $x_3$ is 0.8853. Male labor is the main decision maker in family agricultural producing operation. The average value of $x_4$ is 49.3013. Most agricultural decision makers' age is larger, the time engages in agricultural production is longer, agricultural production experience is abundant. The average value of $x_5$ is 2.7147.

Most decision makers' literacy is between primary school and middle school, and variables are tending to junior high school level. The average value of $x_6$ is 0.6880. Nearly 70% farmers only engage in agricultural production and have no multiple occupation income. The average value of $x_7$ is 8.8682. Farmers' average agricultural acreages are close to 0.6 $hm^2$, but the agricultural areal difference between farmers is large. The fewest agricultural area is 0.03 $hm^2$ and the maximum agricultural area is 5.60 $hm^2$. The average value of $x_8$ is 1.8107. Agricultural level is between superior quality and moderate, the soil fertility is fair. The average value of $x_9$ is 17597. The farmer of the fewest annual net income is 343 yuan, farmer of the maximum income is 23500 yuan. The income gap between farmers is large. The average value of $x_{10}$ is 0.3867. The farmers who have heard "combined circular agriculture" or "agricultural circular economy" are only 38%. The average value of $x_{11}$ is 3.3573. The evaluation of the masses to government technical support force is between general and lesser, which means the technical input of government to country is ongoing. The average value of $x_{12}$ is 0.2053. The farmers who have learned scientific fertilization technology is lesser.

Table 2. List of the average, maximum, minimum and standard deviation of each variable

| Variable | Minimum | Maximum | Average | Standard deviation |
|---|---|---|---|---|
| The farmers fertilizer behavior ($y$) | 0 | 1 | 0.352 | 0.4782 |
| Local traffic condition ($x_1$) | 1 | 5 | 2.4587 | 1.1894 |
| Local communication condition ($x_2$) | 1 | 5 | 2.0533 | 0.9406 |
| Policy-makers' gender ($x_3$) | 0 | 1 | 0.8853 | 0.319 |
| Policy-makers' age ($x_4$) | 23 | 78 | 49.3013 | 10.1025 |
| Policy-makers' literacy ($x_5$) | 1 | 5 | 2.7147 | 0.8597 |
| Policy-makers' multiple occupation situation ($x_6$) | 0 | 1 | 0.688 | 0.4639 |
| Family agricultural acreage ($x_7$) | 0.03 | 5.6 | 0.5912 | 0.5805 |
| Agricultural degree ($x_8$) | 1 | 3 | 1.8107 | 0.6531 |
| Last years' family income ($x_9$) | 343 | 23500 | 17579 | 21119.7628 |
| Cognition degree to combined circular agriculture ($x_{10}$) | 0 | 1 | 0.3867 | 0.4876 |
| Technical support degree of government ($x_{11}$) | 1 | 5 | 3.3573 | 1.0848 |
| Whether have learned scientific fertilization technology ($x_{12}$) | 0 | 1 | 0.2053 | 0.4044 |

## Model estimation process and result

### *Test result of multicollinearity*

Before making regression analysis to sample data, it is necessary to test whether there exists multicollinearity between explanatory variables, if there exists multicollinearity between explanatory variables, then need to adjust explanatory variables, reject and integrate the related variables. Hereby, take each explanatory variable as dependent variable and make multiple linear regression with other explanatory variables so as to judge whether there exists multicollinearity between explanatory variables. First take local traffic condition as dependent variable, other eleven explanatory variables as independent variable to make multiple linear regression. The obtained results are shown in Table 3. Second take local communication condition as dependent variable and make multiple linear regression with other eleven

explanatory variables. Finally take farmer accepts fertilization technology training situation as dependent variable and make multiple linear regression with other eleven explanatory variables. Limited to paper length, this paper lists the multicollinearity of local traffic condition and other eleven explanatory variables to test result. The indexes to measure whether there exist multicollinearity between variables mainly have Tolerance and VIF. Generally speaking, the value range of Tolerance is between [0; 1], if the smaller of Tolerance, it means the higher of multicollinearity probability between this explanatory variable and other explanatory variable, if the bigger of Tolerance, it means the stronger of the independence between explanatory variables; when VIF < 10, then can think there do not exists multicollinearity between variables. Table 3 shows synthesize Tolerance and VIF these two indexes, think there do not exists multicollinearity between explanatory variables, and no need to reject and integrate explanatory variables and save original set twelve explanatory variables.

Table 3. Multicollinearity test between variables

| Dependent variable | Independent variable | Multicollinearity statistic index | |
|---|---|---|---|
| | | Tolerance | |
| local traffic condition ($x_1$) | Local communication condition ($x_2$) | 0.944 | 1.059 |
| | Policy-makers'gender ($x_3$) | 0.857 | 1.167 |
| | Policy-makers'age ($x_4$) | 0.816 | 1.226 |
| | Policy-makers'literacy ($x_5$) | 0.736 | 1.359 |
| | Policy-makers'multiple occupation situation ($x_6$) | 0.902 | 1.108 |
| | Family agricultural acreage ($x_7$) | 0.85 | 1.176 |
| | Agricultural degree ($x_8$) | 0.968 | 1.033 |
| | Last years'family income ($x_9$) | 0.915 | 1.093 |
| | Cognition degree to combined circular agriculture ($x_{10}$) | 0.877 | 1.140 |
| | Technical support degree of government ($x_{11}$) | 0.923 | 1.083 |
| | Whether have learned scientific fertilization technology ($x_{12}$) | 0.937 | 1.067 |

## *Test result of fit goodness*

In binary logistic regression model, Hosmer and Leme show test is the frequently-used fit goodness testing method. Under the situation of existing continuous variable in explanatory variable, or the number of sample is less, Hosmer and Leme Test is more credible than traditional Chi-square testing result. The null hypothesis of Hosmer and Leme show Test is the actual value and estimated value of model variable can not exist any differences, alternative hypothesis is the totally difference between actual value and estimated value. If significance larger than 0.05, then cannot refuse null hypothesis, think the fitting between actual value and estimated value of model is good. On the study about farmer fertilize input model, the Chi-square value is 5.786, significance level is 0.671, cannot refuse null hypothesis, which means model fitted good (Table 4).

Table 4. Hosmer and Leme show test

| Step | Chi-square value | Degree of freedom | Significance level |
|---|---|---|---|
| 1 | 5.786 | 8 | 0.671 |

In binary logistic regression model, the Omnibus test of model coefficient provides the significance level of model coefficient obtained from traditional Chi-square testing. The idea of Omnibus testing is to test whether the models include independent variables are different with the models only include intercept term, so as to analyze the relationship between explanatory variable and explained variable of model. The testing result in Table 5 shows the models pass Omnibus testing with the significance level of 0.01, the model fitted well, at the same time also means there at least exists one explanatory variable which is remarkably correlated with explained variable. The results of step, block and model in Table 5 is the same. The aim to list all them is to show testing steps more clearly.

Table 5. Omnibus testing of model coefficient

| | | **Chi-square** | **Degree of freedom** | **Significance level** |
|---|---|---|---|---|
| Step 1 | Step | 40.114 | 12 | 0.0000 |
| | Block | 40.114 | 12 | 0.0000 |
| | Model | 40.114 | 12 | 0.0000 |

## *Estimation result of model*

Make logistic regression to farmer incremental input model with SPSS16.0 software, choose Enter as regression method. The standardized coefficient is obtained manual computation through the following algorithm [13]:

$$\beta_i = \frac{b_i \times s_i}{\pi / \sqrt{3}} \approx \frac{b_i \times s_i}{1.8138} \tag{3}$$

where $\beta_i$ is the standardized regression coefficient of the $i$ independence; $b_i$ is the unstandardized regression coefficient of the $i$ independent variable; $s_i$ is the standard deviation of the $i$ independent variable; $\pi / \sqrt{3}$ actually is the standard deviation of standard logistic distribution, which approximately equal to 1.8138. Through logistic regression analysis found that the gender of farmer decision makers, family agricultural acreage, cognition degree of farmer to combined circular agriculture, government technical support dynamics have obvious significance to farmer fertilizer behavior. Where the biggest variable is family agricultural acreage (0.1632), respectively is the cognition degree of farmer to combined circular agriculture (–0.1588) and government technical support force (0.1405), the smallest variable is the gender of farmer production decision makers (0.1378).

Specifically, the gender of agricultural production decision makers have prominent positive influence to farmer fertilizer applicative situation, contrast to male decision makers, female agricultural decision makers are more tend to the decremental fertilizer application. In China's rural areas, the vast majority of family decision makers are male, and male laborers master economic decision-making power.

Family agricultural acreage has significant positive influence to farmers' fertilizer behaviors, the farmers with more agricultural acreages are more tend to incremental fertilization in agricultural production [4]. The families with more agricultural acreages have more rural income, farmers paid more attention to agricultural production and willing to make larger scale investment to agriculture. Under the temporal circumstance of lacking conventional agricultural production technology and field management technology, this "generous" investment often expresses as the superfluous investment of fertilizer, pesticide and

agricultural film [5]. Therefore, how to find the equilibrium point between scale operation and science operation, to make farmers' "generous" investment transformed to rational management, realize the "two-win" of economic effect and ecological effect is a subject which worth our further study. Farmers' combined circular agricultural cognition degree has significant negative influence to fertilizer behaviors, contrast to the farmers without combined circular agricultural concept, and the farmers only have heard "combined circular agriculture" or "rural circular economic" are more tend to the decremental fertilizer application.

Government support to farmers fertilizer application behaviors has positive influence, the areas with low government support, farmers are more tend to incremental fertilizer application during production; the areas with big government support, farmers decremental fertilizer application behavior is more obvious, which means governmental agricultural technology support and technology promotion have significant importance to agricultural production [8]. At the present stage, most of Chinese peasants are still in agricultural production with traditional farming experience, agricultural conventional production technique is insufficiency, farmer fields management level is low. Under this circumstance, a small amount of government input to agricultural technology promotion will play a good effective. Such as government make trainings of soil testing or formulation will avoid farmers enter into the wrong region of excess fertilization, in turn into the exact orbit of decremental application.

## Conclusion and countermeasure

Through the above analysis can obtain following conclusions, only under "incremental application" and "decremental application" these two choices, most farmers tend to the decremental utilization of fertilizer"; in addition, the gender, family agricultural acreage of agricultural production decision makers, the cognition degree, government technical support degree of farmers to combined circular agriculture all have obviously impact on fertilizer application behaviors, here proposes following countermeasures based on research results.

(1) One incentive object should especially pay attention to the guidance and encourage to agricultural production large-scale growers and women. This is incorporated in increase of the technical support and operating guiding to production large-scale growers, which not only can increase income, improve returns to scale, but also has a good demonstration role to surrounding farmers; transfer of women's active awareness in combined circular agricultural production, strengthening of the technical training to women that can not only improve the agricultural operation and management level to farmers, but can also have a significant meaning to the improvement of rural women's status, and the promotion of rural democracy construction.

(2) Improving the cognition degree of farmers with respect to combined circular agriculture. At present, the cognition degree of farmers with respect to combined circular agriculture is low, which enormously influences the development of combined circular agriculture and the "two subtypes" social construction. Therefore, the combined circular agricultural theory should be popularized; both by the promotion of government departments, but also with the attention and support of the whole society. Getting more people to realize that the combined circular agriculture is the important constituent part of circular economy, concerns the Chinese economic structural adjustment and future economic development direction.

(3) Reinforcement of governmental technical support. The governmental technical promotion and support have a significant importance to combined circular agricultural development, therefore should strengthen the technical promotion of government department concerned, while increasing the training frequency to farmers, choosing applicative routine techniques to promote, improve training ways, as well as strengthening of the technical demonstration. It needs to increase farmers' technical expertise, and encourage farmers to apply their learned technology into actual productions, so that the "decremental input" theory enjoys popular support.

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