Factors of Influencing the Development of Low Carbon Agriculture in Hunan Province

Yong Zhang\(^{1,2,a}\), Bei Zhang\(^{1,2}\), Xiaohua Wan\(^{1}\), Pei Tang\(^{1,2}\), Teng Cheng\(^{1,2}\), Yang Cao\(^{1,2,3}\)

\(^{1}\)School of Architecture and Urban Planning, Hunan University of Science and Technology, Xiangtan 411201, China
\(^{2}\)School of Education, Hunan, Hunan University of Science and Technology, Xiangtan 411201, China
\(^{3}\)Mingde Dongjing Middle School, Changsha 410116, China
\(^{a}\)292278@qq.com

Abstract

This paper takes Hunan Province as an example to study the development of low carbon in agriculture. Through regression analysis of the total output value of agriculture with the fertilizer application amount, the total power of agricultural machinery and crop planting area, the results showed that the total power of agricultural machinery is one of the important factors that influenced the total output value of agriculture, followed by the fertilizer application amount. Therefore, during the process of agricultural mechanization in Hunan Province, it should pay attention to energy consumption and greenhouse gas emissions, so as to promote the development of low carbon agriculture.

Keywords

Low carbon agriculture, influential factors, regression model.

1. Introduction

According to the Fourth Assessment Report of the United Nations Intergovernmental Panel on climate change in 2007, the global temperature will increase by 1.1-6.4°C due to global warming in the next 100 years, and sea level will rise by 18-59cm [1]. As it is known to all, the main cause of global warming is the increasing the greenhouse gas concentration in the atmosphere. According to statistics, among the greenhouse gases released by human activities, CO\(_2\), CH\(_4\) and N\(_2\)O discharged by the agricultural production accounted for about 21%-25%, 57% and 65%-80% of the total respectively [2]. Although the agricultural itself has the strong carbon absorption capacity, with the extensive use of agricultural machinery and chemical fertilizers, agricultural ecological environment continues to be affected and damaged by the pollution. The direct results are that the carbon absorption capacity is reduced, and the greenhouse gas emission from agricultural production environment is increasing continuously. Therefore, in order to cope with climate change, vigorously develop low-carbon agriculture has become an important measure for sustainable development of agriculture.

Low carbon agriculture is referred to a new type of agriculture with multi function of "agricultural production, safety and security, climate regulation, ecological conservation, rural finance". It is committed to promoting energy conservation and emission reduction technologies, developing of biomass energy and renewable energy in the field of agriculture. And its new feature is "low energy consumption, low emission, low pollution" [3]. Developing low carbon agriculture, cutting down
energy consumption and reducing greenhouse gas emissions is a new model for promoting the stability and balance of the agricultural ecosystem and ensuring the safe production of agriculture. At the same time, it is also an urgent need to improve the rural environment and the quality of farmers' life.

2. Carbon emissions in the process of agricultural production

In the process of agricultural production, greenhouse gas emissions are mainly by changing CO₂, CH₄, N₂O at the interface between the soil and the atmosphere exchange [4]. Chinese scholars used biogeochemical process model (DNDC) in 1990 to estimate the agricultural greenhouse gas emissions of China. The results showed that CO₂, CH₄ and N₂O emissions of Chinese agriculture ecological systems were about 95 million tons C/year, 9.2 million tons C/year and 1.3 million tons C/year respectively [4]. Therefore, the greenhouse gas emissions in the agricultural production activities are one of the reasons for the increase of greenhouse gas concentrations in the atmosphere. Carbon emissions of agricultural production mainly come from the following two aspects (Fig. 1):

2.1 Carbon emissions from inside the agricultural system

Carbon inputs mainly include the respiration of crops and soil, the using process of fertilizer and pesticide, consumption of agricultural machinery (electric power and energy) and other indirect carbon input. As a matter of fact, the largest carbon pool is the soil for the agricultural ecosystem. Pedosphere is an important storage library and converter of carbon. Its organic carbon content accounted for three-quarters of carbon of the entire biosphere, and it is the largest carbon pool [5]. Soil respiration makes large amounts of organic carbon release into the atmosphere in the form of CO₂. It is estimated that the amount of carbon released by the soil is about (0.8 ~ 4.6) x 10¹⁵g [6]. In general, in the process of crop growth, the rice field discharges CH₄, and farmland discharges N₂O [7]. Under the conditions of plant, vegetation, soil and human disturbance, organic matter of soil can be decomposed into inorganic carbon (C) and nitrogen (N) [4]. Inorganic carbon is released into the atmosphere in the form of CO₂ under aerobic conditions, and the CH₄ can be produced under anaerobic conditions. A large number of applications of chemical fertilizer accelerate the mineralization of soil organic carbon, and then, a large number of greenhouse gases, such as CO₂ and CH₄, are discharged into the atmosphere [8]. Annual CH₄ emissions of paddy soil accounted for 10%-15% of the global CH₄ emissions [6]. In addition, energy consumption (diesel, gasoline, etc.) of machinery is also a source of greenhouse gas emissions.

2.2 Carbon emissions from the external environment of agriculture

It mainly includes two aspects: the process of human being to agriculture and the waste of the animal. The process of human being to agriculture mainly includes burning of carbonaceous fuels, Energy and material consumption in processing and circulation of agricultural products and the changes of land-use pattern, etc. Some studies have indicated that the change of land-use is the second largest source of carbon in the atmosphere, and its effect is only next to the burning of fossil fuels [9]. Due to the change of land-use, the annual discharge is 1.6PgC/a to the atmosphere, accounting for about 20% of the total emissions from human activities [10]. In addition, there are greenhouse gas emissions from other wastes such as animal manure.

Carbon emission from agricultural production has a significant impact on the concentrations of atmospheric greenhouse gas concentrations. At the same time, global warming has a great impact on agricultural production. Climate warming has also brought a series of problems to agricultural production, such as a more fragile agricultural ecological environment, the increasing frequency of drought and flood disasters, unstable crop yield, constantly intensifying pests and diseases, agricultural construction investment increasing and food security risks. Dealing with climate change and developing low-carbon agriculture is the only way to realize the harmonious development of society, economy and ecology.
3. Necessities of developing low carbon agriculture in Hunan Province

Hunan Province, located in the middle reaches of the Yangtze River and South of Dongting Lake, is a major agricultural province with superior geographical position. The total population of agriculture was 50770000 in 2008. It covers an area of 210000 square kilometers. Among them, the farmlands' area, hillocky and mountainous' area and the area of river and lake are 57500000 acres, 256 million acres and 20430000 acres respectively. Its climate is subtropical monsoon climate with rich heat resources, adequate illumination, long frost-free period. This weather condition is very favorable for the development of agriculture. From 2001 to 2008, the gross output value of agriculture in Hunan Province has been growing steadily (Fig. 2).

Fig. 2 Growth trend of total output value of agriculture, forestry, animal husbandry and fishery in Hunan Province from 2001 to 2008
In recent years, with the rapid development of agriculture in Hunan Province, 50 new agricultural standardization demonstration areas are built, and the agricultural industrialization and production capacity have greatly improved in 2008. The output of the main agricultural products, such as the paddy, cotton, oil plants, sugar cane and tea, is relatively stable (Fig. 3).

Based on Fig. 3, among the main agricultural products of Hunan Province, rice has a large proportion. In the total area of cultivated land, paddy fields accounted for 87% in 2008. However, paddy fields usually discharge CH$_4$. So, large areas of paddy fields will increase the amount of greenhouse gas emissions. In recent years, the use of agricultural fertilizers and pesticides in Hunan Province increased year by year. Especially in 2008, the application amount of chemical fertilizer and pesticide reached 223.38 and 11.28 tons respectively, but the utilization ratio is not high. Unreasonable and excessive use of fertilizers and pesticides will not only damage the soil structure, and even lower soil fertility, but also increase the N$_2$O emissions. As a result, the concentration of greenhouse gases is increased, and the environment is polluted.

![Fig. 3 Output of major agricultural products in Hunan Province (10000 tons)](image)

Agriculture is the fundamental and the strategy. In the pursuit of production, protecting the ecological environment of agriculture is conducive to the stability of the agricultural base and the improvement of the production environment. Therefore, the development of low carbon agriculture, establishment of agricultural recycling mechanism and achievement of safe and green production are the inevitable choice for the low carbon economy and the new rural construction in Hunan Province. Simultaneously, it is the only way to realize the sustainable development of society, economy and ecology.

**4. Multivariate linear regression model and result analysis**

**4.1 Principle of the regression model**

The gross output value of agriculture is not only affected by one factor, but the result of many factors. The multiple linear regression model is a theory and method to study the relationship between one dependent variable and multiple independent variables. Its principle is as follows:

The structure form of the multiple linear regression model is:

$$y_a = \beta_0 + \beta_1 x_{1a} + \beta_2 x_{2a} + \ldots + \beta_h x_{ha} + \epsilon_a$$  \hspace{1cm} (1)
Regression equation:

\[ \hat{y} = b_0 + b_1 x_1 + b_2 x_2 + \ldots + b_k x_k \]  (2)

\( b_0 \) is a constant, \( b_1, b_2, \ldots, b_k \) are partial regression coefficients. The significance of the partial regression coefficient is a numerical value which makes an average change of the dependent variable while one unit per change of the independent variable.

According to the principle of the least square method, \( b_i (i = 0,1,2,\ldots,k) \), as an estimated value of \( \beta_i (i = 0,1,2,\ldots,k) \), should meet:

\[ Q = \sum_{a=1}^{n} (y_a - \hat{y}_a)^2 = \sum_{a=1}^{n} [y_a - (b_0 + b_1 x_{1a} + b_2 x_{2a} + \cdots + b_k x_{ka})]^2 \rightarrow \min \]  (3)

According to the necessary conditions for the extreme value, it can be obtained:

\[
\begin{align*}
\frac{\partial Q}{\partial b_0} &= -2 \sum_{a=1}^{n} (y_a - \hat{y}_a) = 0 \\
\frac{\partial Q}{\partial b_j} &= -2 \sum_{a=1}^{n} (y_a - \hat{y}_a)x_{ja} = 0 (j = 1,2,\ldots,k)
\end{align*}
\]  (4)

Equation (4) is called the normal equation group. Introduce the following matrices:

\[
X = \begin{bmatrix}
1 & x_{11} & x_{21} & \cdots & x_{k1} \\
1 & x_{12} & x_{22} & \cdots & x_{k2} \\
1 & x_{13} & x_{23} & \cdots & x_{k3} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
1 & x_{1n} & x_{2n} & \cdots & x_{kn}
\end{bmatrix}
\]  (5)

\[
A = X^T X = \begin{bmatrix}
1 & 1 & 1 & \cdots & 1 \\
x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\
x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
x_{k1} & x_{k2} & x_{k3} & \cdots & x_{kn}
\end{bmatrix}
\begin{bmatrix}
1 & x_{11} & x_{21} & \cdots & x_{k1} \\
1 & x_{12} & x_{22} & \cdots & x_{k2} \\
1 & x_{13} & x_{23} & \cdots & x_{k3} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
1 & x_{1n} & x_{2n} & \cdots & x_{kn}
\end{bmatrix}
\]  (6)

\[
B = X^T Y = \begin{bmatrix}
1 & 1 & 1 & \cdots & 1 \\
x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\
x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
x_{k1} & x_{k2} & x_{k3} & \cdots & x_{kn}
\end{bmatrix}
\begin{bmatrix}
y_1 \\
y_2 \\
y_3 \\
\vdots \\
y_n
\end{bmatrix} = \begin{bmatrix}
\sum_{a=1}^{n} y_a \\
\sum_{a=1}^{n} x_{1a} y_a \\
\sum_{a=1}^{n} x_{2a} y_a \\
\vdots \\
\sum_{a=1}^{n} x_{na} y_a
\end{bmatrix}
\]  (7)

\[ Y = \begin{bmatrix}
y_1 \\
y_2 \\
y_3 \\
\vdots \\
y_n
\end{bmatrix}
\]
Introduce marks:
\[ L_y = L_y = \sum_{a=1}^{n} (x_{ia} - \bar{x}_i)(x_{ja} - \bar{x}_j)(i, j = 1, 2, \cdots, k) \]  \hspace{1cm} (8)
\[ L_y = \sum_{i=1}^{n} (x_{ia} - \bar{x}_i)(y_a - \bar{y})(i = 1, 2, \cdots, k) \]  \hspace{1cm} (9)

Significance test of the regression model:
① Regression sum of squares \( U \) and residual sum of squares \( Q \):
\[ S_{Total} = L_{yy} = U + Q \]
② Regression sum of squares:
\[ U = \sum_{a=1}^{n} (\hat{y}_a - \bar{y})^2 = \sum_{a=1}^{n} b_i L_y \]
③ Residual sum of squares:
\[ Q = \sum_{a=1}^{n} (y_a - \hat{y}_a)^2 = L_{yy} - U \]
④ The F statistic is:
\[ F = \frac{U/k}{Q/(n - k - 1)} \]

4.2 Data selections and the establishment of a regression model

The gross output value of agriculture is influenced by many factors, such as crop area, the amount of fertilizer application, agricultural power machinery, technical and capital investment, labor input. But for the carbon cycle in the process of agricultural production (Fig. 1), the sources of the agricultural carbon emission mainly come from the use of fertilizer in agriculture, energy consumption of agricultural machinery, role of crop respiration and burning of carbon containing fuels etc. Therefore, three indicators (total power of agricultural machinery, the amount of fertilizer application and crop sown area) which have significantly affected the agricultural carbon emissions were selected to carry out regression analysis in this paper (Table 1). And try to find out the main source of carbon emission in the process of agricultural production in Hunan Province.

Let the gross agricultural output value as a dependent variable \( y \), and let the total power of agricultural machinery, fertilizer application amount and the total sown area of crops as the independent variables \( x_1 \), \( x_2 \), \( x_3 \) respectively. Regression models can be established:
\[ y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + e \]

In the formula, \( a \), \( b_1 \), \( b_2 \) and \( b_3 \) are the partial regression coefficient, and \( e \) is the disturbance term. The values of partial regression coefficients are obtained by the least square method (OLS). That is, \( a \), \( b_1 \), \( b_2 \) and \( b_3 \) are used as the best estimate value while the sum of square errors reaches the minimum. The significance test of regression equation uses statistic \( F \).

4.3 Test and analysis of the results of regression

First of all, the ordinary least square method is used to estimate the initial regression model, and the output of the measurement is shown in Table 2. According to the partial regression coefficients in Table 2, it can get the following regression equation:
\[ y = -461.573 + 0.48027 x_1 + 17.4689 x_2 + 4.320927 x_3 \]

Standard error value: \( (0.038155) \), \( (2.23505) \), \( (3.190785) \)

\( T \) value: \( (12.58725) \), \( (7.815887) \), \( (1.354189) \)
From the statistical results of regression analysis, the complex correlation coefficient R is 0.992; the coefficient of determination is 0.984; and the adjustment coefficient is 0.968. The fitting degree of the equation is higher. \( R^2 = 0.984 \) shows that 3 explanatory variables can explain the total variation of the 98.4%. Because the F statistical value of the regression equation is 158.439, \( R = 0.0000 \), the regression model is very significant in general. DW test (Durbin-Watson) value is 1.417, which shows that the residual term does not have a first-order autocorrelation. Under the significant level of 0.05, probability value p of the coefficient t value of variable \( x_1 \) and variable \( x_2 \) is less than 0.05. This shows that the total power of agricultural machinery and fertilizer consumption have a significant impact on the gross output value of agriculture.

Table 1 Gross output value of agriculture, the total power of machinery, the application of fertilizer and the sown area of crops in Hunan Province

<table>
<thead>
<tr>
<th>Year</th>
<th>Gross output value of agriculture (100 million Yuan)</th>
<th>Total power of agricultural machinery (10000 kw)</th>
<th>Application of fertilizer (10000 tons)</th>
<th>Total sown area of crops (10000 hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>665.70</td>
<td>2358.02</td>
<td>184.25</td>
<td>793.17</td>
</tr>
<tr>
<td>2002</td>
<td>666.65</td>
<td>2498.09</td>
<td>184.32</td>
<td>777.92</td>
</tr>
<tr>
<td>2003</td>
<td>671.66</td>
<td>2664.45</td>
<td>188.33</td>
<td>773.12</td>
</tr>
<tr>
<td>2004</td>
<td>874.00</td>
<td>2923.93</td>
<td>203.19</td>
<td>818.87</td>
</tr>
<tr>
<td>2005</td>
<td>947.70</td>
<td>3189.86</td>
<td>209.90</td>
<td>833.63</td>
</tr>
<tr>
<td>2006</td>
<td>1023.51</td>
<td>3416.61</td>
<td>212.14</td>
<td>853.19</td>
</tr>
<tr>
<td>2007</td>
<td>1243.15</td>
<td>3684.43</td>
<td>219.58</td>
<td>853.64</td>
</tr>
<tr>
<td>2008</td>
<td>1446.87</td>
<td>4021.14</td>
<td>223.38</td>
<td>793.95</td>
</tr>
</tbody>
</table>

Note: Data source: Hunan Statistical Yearbook from 2001 to 2009.

Table 2 Tests of regression analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>t value</th>
<th>Probabilities of the P</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x_1 )</td>
<td>0.48027</td>
<td>0.038155</td>
<td>12.58725</td>
<td>1.54E-05</td>
</tr>
<tr>
<td>( x_2 )</td>
<td>17.4689</td>
<td>2.23505</td>
<td>7.815887</td>
<td>0.000231</td>
</tr>
<tr>
<td>( x_3 )</td>
<td>4.320927</td>
<td>3.190785</td>
<td>1.354189</td>
<td>0.224452</td>
</tr>
</tbody>
</table>

Table 3 Correlation coefficient matrix

<table>
<thead>
<tr>
<th>Variable</th>
<th>Gross output value of agriculture (100 million yuan) ( y )</th>
<th>Total power of agricultural machinery (10000 kW) ( x_1 )</th>
<th>Amount of fertilizer application rate (10000 tons) ( x_2 )</th>
<th>Total sown area of crops (10000 hectares) ( x_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross output value of agriculture (100 million yuan) ( y )</td>
<td>1.000</td>
<td>0.982</td>
<td>0.954</td>
<td>0.484</td>
</tr>
<tr>
<td>Total power of agricultural machinery (10000 kW) ( x_1 )</td>
<td>0.982</td>
<td>1.000</td>
<td>0.977</td>
<td>0.547</td>
</tr>
<tr>
<td>Amount of fertilizer application rate (10000 tons) ( x_2 )</td>
<td>0.954</td>
<td>0.977</td>
<td>1.000</td>
<td>0.677</td>
</tr>
<tr>
<td>Total sown area of crops (10000 hectares) ( x_3 )</td>
<td>0.484</td>
<td>0.547</td>
<td>0.677</td>
<td>1.000</td>
</tr>
</tbody>
</table>
As it can be seen from Table 3, the correlation coefficient between the total power of agricultural machinery and the gross output value of agriculture is 0.982, and the correlation is the highest. The next is the correlation coefficient between the fertilizer application amount and the gross output value of agriculture, whose value is 0.954; The correlation coefficient between the total sown area and the gross output value of agriculture is 0.484, and the correlation was not significant. This result shows that the increase of gross output value of agriculture is realized by the popularization of agricultural mechanization and the increase of the amount of fertilizer application.

Fig. 4 is the residual distribution of the total power of agricultural machinery. Gross output value of agriculture has a linear relationship with the total power of agricultural machinery. The regression coefficient, regression constant and correlation coefficient is 0.0002, 1203.9 and 0.9635 respectively. The regression equation is:

\[ y = 0.0002x + 1203.9 \]

From the results of the regression analysis, the bigger influence factor in the gross output value of agriculture is the total power of agricultural machinery, followed by the application of fertilizer. However, the sown area of crops had little influence on the gross output value of agriculture. The main reason is the crop planting area will not change much every year. But, with increasing life level and the income of farmers, more and more agricultural machineries are put into production. Although, on the one hand, it improves the level of agriculture mechanization, at the same time, it also increases the concentrations of greenhouse gases in the atmosphere due to the amount of higher energy consumed by agriculture machinery.

4.4 Analysis of agricultural greenhouse gas emission in Hunan Province

Table 4 is the statistics of the use of agricultural diesel oil and carbon emissions in Hunan Province during 2001-2008. In order to calculate the total amount of carbon emissions produced by agricultural machinery, it needs to convert the use of diesel oil into standard coal. In this paper, the new Chinese
national standard 2589-2008 GB/T, which was formally implemented on June 1, 2008, is adopted. The conversion coefficient of the use of diesel oil is 1.4571 kg standard coal/kg. Then, according to the calculation method of the amount of CO\textsubscript{2} released from fossil fuel combustion released by ORNL, the carbon emissions generated by combustion diesel oil were calculated [12]. The calculation formula is: (the carbon emission of fuel) = (standard coal equivalent) \times 0.73257 \times 0.813 \times 0.982. In the formula, 0.982 is the effective oxidation fraction; 0.73257 is carbon content per ton of standard coal; 0.813 is the multiple CO\textsubscript{2} released by oil compared with CO\textsubscript{2} released by coal in the case of obtaining the same thermal energy. Change trend of carbon emission due to the use of diesel in agricultural machinery is shown in Fig. 6.

Table 4 Amounts of carbon emissions from the agricultural use of diesel oil in Hunan Province during 2001-2008

<table>
<thead>
<tr>
<th>Year</th>
<th>Usage amount of agricultural diesel oil (10000 tons)</th>
<th>Equivalent to standard coal (10000 tons)</th>
<th>Carbon emissions (10000 tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>24.74</td>
<td>36.05</td>
<td>21.08</td>
</tr>
<tr>
<td>2002</td>
<td>25.50</td>
<td>37.16</td>
<td>21.73</td>
</tr>
<tr>
<td>2003</td>
<td>27.68</td>
<td>40.33</td>
<td>23.59</td>
</tr>
<tr>
<td>2004</td>
<td>30.20</td>
<td>44.00</td>
<td>25.74</td>
</tr>
<tr>
<td>2005</td>
<td>32.64</td>
<td>47.56</td>
<td>27.82</td>
</tr>
<tr>
<td>2007</td>
<td>33.54</td>
<td>48.87</td>
<td>28.58</td>
</tr>
<tr>
<td>2008</td>
<td>35.65</td>
<td>51.95</td>
<td>30.38</td>
</tr>
</tbody>
</table>

Note: All data are from Hunan statistical yearbook. Because the use of agricultural diesel oil in 2006 did not count in the Yearbook, the data of 2006 did not count in this statistics. ng References, see Fig. 1.

Fig. 6 Change trend of carbon emissions from agricultural use of the diesel oil in Hunan Province from 2001 to 2008

As it can be seen from Fig. 6, with the increase of diesel fuel in the combustion of agricultural machinery, carbon emissions also showed an increasing trend. Due to a significant correlation between the total power of agricultural machinery and the gross output value of agriculture, carbon emissions of agricultural mechanization production should be paid attention to reduce greenhouse gas emissions and improve the agricultural ecological environment.
As a result of the increase use of fertilizers and pesticides, while increasing soil fertility and crop yield, a negative impact on the agricultural ecological environment is brought about (Fig. 7).

![Diagram of fertilizer types and proportions](image)

Fig. 7 Types and proportion of fertilizer used in Hunan Province in 2008

In the amount of agricultural fertilizer application, the amount of nitrogen fertilizer application accounted for 51%. Excessive use of nitrogen fertilizer in the field will result in the emission of N₂O in soil [4]. In fact, the application of urea also resulted in the increase of CO₂ concentration in the atmosphere.

5. Conclusions and recommendations

In this paper, regression analysis was carried out for the gross output value of agriculture with the amount of fertilizer, the total power of agricultural machinery and crop planting area. The results showed that the total power of agricultural machinery is one of the important factors that influenced the total output value of agriculture, followed by the amount of fertilizer. Therefore, the development of low carbon agriculture in Hunan Province should pay attention to the following points:

1. The use of agricultural machinery should minimize the energy consumption. While promoting agricultural mechanization, it should minimize the consumption of fossil fuels and find alternative sources of energy.

2. Scientific uses of fertilizer, improving technique of fertilizer application. Reduce CO₂ to atmospheric emissions through organic fertilizer applied to the soil, slowing down the decay of soil organic matter, shortening the exposure time of the organic manure, reducing land farming activities and improving soil water management. At the same time, undertake fertilization according to the crop needs to avoid excess nitrogen in the soil and reduce the emissions’ amount of N₂O.

3. Straw returning to a field. The burning of straw not only releases carbon directly, but also accelerates the loss of soil organic carbon. Straw returning to the field cannot only alleviate the soil organic carbon, but also can improve the soil fertility. Studies have indicated that the most direct and effective measure to reduce the CO₂ emission of farmland is to increase the proportion of the ground straw returning to a field [5].

4. Reduce the use of pesticides and promote the replacement of pesticides. Popularize biological control and physical control of pests broadly, develop ecological agriculture vigorously, strengthen the agricultural green and safe production, and maintain the balance of agricultural ecology.

5. Rational use and protection of cultivated land resources. Through improving the land use, effectively protecting the cultivated land and improving the soil environment make the soil become a carbon sink. Thereby, the carbon emissions of the agricultural production process are reduced.
Acknowledgements

Financial support from teaching reform project of “The research and practice of cooperative education mode of geographical science” (supported by Hunan Provincial Education Department); Project of Science and Technology Department of Hunan Province (2013RS4053); Social Science Fund of Hunan Province (12YBA136).

References


