Prediction of Agricultural plastic agricultural plastic film use based on combined prediction model

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Abstract. Although increasing the yield of crops, the large-scale use of agricultural plastic film in agricultural production, has caused damage to the ecological environment. This paper analyzes the current situation of the use of plastic agricultural plastic film in China from 1999 to 2015. The GM(1, 1) model and the ARIMA(0, 2, 0) model are used to predict the mulch usage, and then the optimal weight combination method is used to obtain the grey-time series combination prediction model. The results show that the accuracy of synthetic prediction model is higher than that of the single model and has better applicability. The prediction results of the combined model can be used as a reference for the scientific use and management of agricultural plastic film in China.

1. Introduction
As the world's total population continues to grow, food supplies are under unprecedented pressure. In order to increase the output of food to meet human needs, a large number of membranes are used in agricultural production. It is mostly made of polyethylene and has extremely difficult to degrade properties. Over time, it has a negative impact on soil productivity and ecology. At present, ecological research scholars have carried out research on related issues: the use of combined models to analyze and predict water quality, the evaluation and prediction of cultivated land ecological security values, the prediction of agricultural plastic agricultural plastic film demand, and the side effects of food production.

In China, plastic agricultural plastic agricultural plastic film is widely used in arid and semi-arid areas in the north and mountainous and cold areas in the south. Analysis of the 1998 and 2014 China Agricultural Statistical Yearbook and the statistical table in the environmental data of the National Bureau of Statistics, "The use of agricultural plastic agricultural plastic agricultural plastic film and pesticides in various regions", we can see that the use of plastic agricultural plastic agricultural plastic film in Shandong, Xinjiang and Sichuan accounted for the largest proportion. In 2014, the three provinces used 3.01×10⁵ tons, 2.63×10⁵ tons and 1.30×10⁵ tons of mulch. The use of plastic agricultural plastic agricultural plastic film in China is characterized by uneven regional distribution and strong influence by agricultural technology. The problem of predicting the use of mulch agricultural plastic agricultural plastic film in China is studied, and the combination of optimal
weights is used to construct a combined forecasting model. The mulch use in China with a time series span of 1999 and 2015 was analyzed, and a reasonable prediction was made for the use of mulch agricultural plastic agricultural plastic film in 2016 to 2025. In order to accurately grasp the development rules and changing trends of the Chinese plastic agricultural plastic agricultural plastic film market, and provide a reference for the development of plans for the production, import, treatment and disposal of related enterprises, it is convenient for the government to manage the recycling of used agricultural plastic agricultural plastic film.

2. Data Sources
Agricultural indicators in the annual data of the National Bureau of Statistics, the China Agricultural Statistical Yearbook from 1998 to 2014, and the statistical table in the environmental data of the National Bureau of Statistics, “Use of agricultural plastic agricultural plastic agricultural plastic film and pesticides in various regions”.

3. Research method

3.1. GM(1, 1) model
The original sequence was established using the 1999-2015 agricultural plastic agricultural plastic film index in China.

\[ x^{(0)} = \{ x^{(0)}(1), x^{(0)}(2), ..., x^{(0)}(17) \} \]

Dosum summation for \( x^{(0)} \).

\[ x^{(1)}(i) = \sum_{k=1}^{i} x^{(0)}(k) \quad (i = 2, 3, ..., 17) \]  

Take the weighted mean of \( x^{(1)} \).

\[ z^{(1)}(k) = \alpha x^{(1)} + (1 - \alpha) x^{(1)}(k - 1) \quad (k = 2, 3, ..., 17) \]

\( \alpha \) is to determine the parameters.

The white differential equation is given by the following equation, where is the development gray number and b are the endogenous control gray number.

\[ \frac{dx^{(1)}}{dt} + az^{(1)}(k) = b \]

For taking \( x^{(0)}(k) \) as the gray derivative and \( z^{(1)}(k) \) as the background value, the gray differential equation can be obtained as follows.

\[ x^{(0)}(k) = az^{(1)}(k) = b \quad (k = 2, 3, ..., 17) \]

Get the corresponding predicted value.

\[ \hat{x}^{(0)}(k+1) = x^{(1)}(k+1) - \hat{x}^{(1)}(k) = (x^{(0)}(1) - \frac{b}{a}) (e^{-ak} - e^{-ak(k-1)}) \]

3.2. ARIMA(p, d, q) model
Linear fitting of raw data using Eviews 9, analysis of Figure 1 shows that the Chinese Agricultural plastic agricultural plastic film use sequence depends on the time change, the overall upward trend, is a non-stationary time series, but there is no obvious seasonal variation trend. Therefore, it is considered to use the time series prediction model for prediction.

\[ \hat{x}_t = \mu + \Phi_1 x_1 + ... + \Phi_p x_{t-p} + \theta_1 x_{1-d} + ... + \theta_q x_{1-q} \]

The \( \Phi \) is the autoregressive coefficient, however, \( \theta \) is the moving average coefficient, and \( p, d, q \) is the regression order, the number of splits, and a moving average of order.
3.3. Combined forecasting model

Using the optimal weight recombination law, and using the GM(1, 1) model and the ARIMA(p, d, q) model to obtain the predicted value of the film use in 1999 and 2025, and the different methods obtained at the same time. The predicted values are combined in a weighted manner to obtain a predicted value.

\[ \hat{x}^{(0)} = \omega \times \hat{x}^{(0)}_1 + (1-\omega) \times \hat{x}^{(0)}_2 \]  

(8)

Figure 1. Fitting curve of Chinese agricultural plastic film use in 1999 and 2015

4. Parameter Selection and Inspection of GM(1, 1) Model

4.1. Parameter Selection and Inspection of GM(1, 1) Model

Using the least squares method, \( (\hat{a}, \hat{b})^T = (B^T B)^{-1} B^T Y \), the parameters \( a = -0.0432 \), \( b = 1322800 \) are obtained, and the fitting value of each season’s mulch film can be obtained by the ash differential equation.

The GM(1, 1) model is tested for post-test difference accuracy, \( C = 0.0761 < 0.35 \), \( P = 1 \). The prediction accuracy of the model is one level, and the prediction result is ideal.

4.2. Order Selection and Test of ARIMA(p, d, q) Model

Using the EViews 9 software to perform unit root test on the ARIMA(p, d, q) model, it is verified that the distribution of the Chinese agricultural plastic film mulching volume with the year does not have a smoothness, so the first-order difference and the second-order differential processing are performed on the original data.

| Cases | Zero-order Differential | First-order differential | Second-order differential |
|-------|-------------------------|--------------------------|--------------------------|
|       | AIC  | SC  | HQ   | AIC  | SC  | HQ   | AIC  | SC  | HQ   |
| case1 | 23.56 | 23.61 | 23.56 | 23.38 | 23.43 | 23.38 | 23.36 | 23.40 | 23.35 |
| case2 | 23.07 | 23.17 | 23.08 | 23.12 | 23.33 | 23.05 | 23.44 | 23.53 | 23.43 |

According to the different items in the test, which test mode is divided into cases 1-3, and which are no additional items, contain drift items, contain trend items and drift items. The value of the information criterion in the three cases is comprehensively analyzed until the second-order differential processing has the case of rejecting the null hypothesis. At this time, the three hypotheses are rejected. It can be seen from Table 1 that when \( d = 2 \), the AIC, SC, and HQ of case 1 are the smallest, that is, the second-order single integer is written as \( I(2) \), and the model is determined as ARIMA(0, 2, 0). Analysis (in Table 2.) shows that the \( P \) value corresponding to the parameters of the ARIMA(0, 2, 0)
model is less than 0.05, so the parameters of the model are considered to be significant, that is, the sequence after the differential processing is a stationary sequence.

Table 2. ARIMA (0, 2, 0) model parameter estimation results

| Transformation method | Coefficient | Standard error | T statistic | P value | Unit root |
|-----------------------|-------------|----------------|-------------|---------|-----------|
| I(2)                  | -1.207456   | 0.317695       | -3.800672  | 0.0022  | -3.800672 |

The I(2) model residual sequence correlation test that shown (in Figure 2.). It can be seen from the autocorrelation and partial autocorrelation graphs of the model residual sequence: when k≥1, the sample autocorrelation function value and the partial autocorrelation function value is both it falls within the 95% confidence interval. In any period of lag, the P value corresponding to the test statistic is far greater than the significance level of 0.05, so the original hypothesis cannot be rejected, and the residual of the model is considered to be a white noise column, so that the model as a whole is significant. It can be used for further predictions.

Figure 2. I(2) model residual sequence correlation test

4.3. Combination prediction model parameter selection

The optimal weight is reorganized, that is, and the variance formula is used for analysis.

\[
S^2 = \frac{1}{n} \sum_{i=1}^{n} (\omega \hat{x}_i^{(0)} + (1 - \omega) \hat{x}_i^{(0)} - x_i)^2
\]  

(9)

When the derivative of the variance function is zero, the variance value is the smallest. The weight coefficient thus obtained is \( \omega = 0.4596 \), \( (1 - \omega) = 0.5404 \), and the above formula is substituted, and the prediction result calculated using the combination model is obtained.

4.4. Model accuracy test

The model is used to evaluate the effect of the model using absolute percentage error. The definition of the average absolute percentage error (MAPE) is less than 10% and the prediction accuracy is higher.

First calculate the relative error between the predicted value and the true value.

\[
\delta = \frac{\Delta/L \times 100\%}{\text{MAPE} = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{y_i^{\text{true}} - y_i^{\text{pred}}}{y_i^{\text{true}}} \right| \times 100\% (i = 1, 2, \ldots, n)}
\]  

(10)
The absolute relative error (MAPE) of the model and combined prediction models will also deteriorate accordingly. The combined forecasting model not only balances the deviation of each single model, but also improves the prediction accuracy. The forecast results show that the use of plastic film in China will continue to grow in the next 10 years. It is predicted that the use of plastic film in agricultural production every year, and it will continue to grow steadily in the next 10 years. It is predicted that the use of plastic film in China will reach 3×10^6 tons in 2025, which is about 1.90 times that of 2005. The average annual growth rate is 7.88×10^4 tons, with an average annual growth rate of 3.00%. Due to the excellent insulation and moisturizing properties of the film, there is no ideal substitute. It is expected that in a short period of time, China's mulch film will still be widely used in agricultural production, and the amount of use will not drop significantly. The resulting ecological environment pollution situation will become increasingly serious, and the level of cultivated land security will also deteriorate accordingly.

5. Results
Between 1999 and 2015, China has a large amount of mulch used in agricultural production every year, and it will continue to grow steadily in the next 10 years. It is predicted that the use of plastic film in China will reach 3.33×10^6 tons in 2025, which is about 1.90 times that of 2005. The average annual growth rate is 7.88×10^4 tons, with an average annual growth rate of 3.00%. Due to the excellent insulation and moisturizing properties of the film, there is no ideal that substitute. It is expected that in a short period of time, China's mulch film will still be widely used in agricultural production, and the amount of use will not drop significantly. The resulting ecological environment pollution situation will become increasingly serious, and the level of cultivated land security will also deteriorate accordingly.

6. Discussion
According to the annual data of Chinese agricultural plastic film use in the National Bureau of Statistics, using EViews 9, SPSS and Matlab software, a combined forecasting model based on the optimal weight combination method was proposed to predict the amount of film used in China from 2016 to 2020.

The combined forecasting model not only balances the deviation of each single model, but also improves the prediction accuracy. The forecast results show that the use of agricultural plastic film in China will continue to grow in the next 10 years. If the amount of mulch film that is extremely difficult to degrade in the next 10 years is increasing, the scope of arable land pollution will continue to expand, and the ecological security and pollution status of arable land will not be optimistic. At present, the global population is still growing, the demand for food production is expanding, and the

| Years | Actual value (Ton) | GM(1, 1) model | ARIMA(0, 2, 0) model | Combined forecasting model |
|-------|-------------------|----------------|----------------------|--------------------------|
|       | Predictive value (Ton) | Relative error (%) | Predictive value (Ton) | Relative error (%) | Predictive value (Ton) | Relative error (%) |
| 2001  | 1449286.00        | 1469583.36      | 1.40                 | 1408657.02 | -2.80                | 1436658.77 | -0.87 |
| 2002  | 1530756.20        | 1534488.99      | 0.24                 | 1559564.19 | 1.88                 | 1548039.63 | 1.13 |
| 2003  | 1591670.34        | 1602261.25      | 0.67                 | 1608664.92 | 1.07                 | 1605712.79 | 0.88 |
| 2004  | 1679985.23        | 1673026.74      | -0.41                | 1649023.00 | -1.84                | 1660055.12 | -1.19 |
| 2005  | 1762325.42        | 1746917.65      | -0.87                | 1764738.64 | 0.14                 | 1756548.11 | -0.33 |
| 2006  | 1845481.83        | 1824072.04      | -1.16                | 1841104.13 | -0.24                | 1833276.18 | -0.66 |
| 2007  | 1937467.94        | 1904634.02      | -1.69                | 1925076.76 | -0.64                | 1915618.28 | -1.12 |
| 2008  | 2006924.27        | 1988754.11      | -0.91                | 2025892.57 | 0.95                 | 2008823.73 | 0.09 |
| 2009  | 2079696.65        | 2076589.44      | -0.15                | 2072819.12 | -0.33                | 2074551.96 | -0.25 |
| 2010  | 2172991.39        | 2168304.11      | -0.22                | 2148907.55 | -1.11                | 2157822.21 | -0.70 |
| 2011  | 2294535.90        | 2264069.45      | -1.33                | 2262724.65 | -1.39                | 2263342.72 | -1.36 |
| 2012  | 2383002.28        | 2364064.37      | -0.79                | 2412518.93 | 1.24                 | 2390249.21 | 0.30 |
| 2013  | 2493183.00        | 2468475.66      | -0.99                | 2467907.18 | -1.01                | 2468168.45 | -1.00 |
| 2014  | 2580211.00        | 2577498.38      | -0.11                | 2599802.24 | 0.76                 | 2589551.39 | 0.36 |
| 2015  | 2603561.00        | 2691336.20      | 3.37                 | 2663677.52 | 2.31                 | 2676389.45 | 2.80 |
large area of mulch is used in cultivated land around the world. The policy recommendations are to increase the research of mulch materials for relevant government departments. Through the work of industry norm-setting and policy revision, the film recycling the processing mode is improved and the Pareto improvement is realized.

![Figure 3. Prediction trend of plastic film use in China in 2001 and 2025](image)

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