Research on Agricultural Planting Optimization Model Based on Nonlinear 0-1 Integer Programming

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Abstract. With the development of the times, people pay more attention to the sustainable development of the rural economy. Planning the planting programme from the maximum planting profit is of great significance to improve the production efficiency and reduce the planting risk, develop organic agriculture, and achieve the sustainable development of rural economy. In order to accurately derive the maximum planting profit of the year, based on nonlinear 0-1 integer planning model and genetic algorithm theory, and using multiple uncertain factors such as arable land type, crop production pattern, cultivation operation and field management and expected sales volume of crops, planting cost in rural areas in the mountainous regions of North China, visualize the data and expand the number of plots, and establish a comprehensive statistical table of crops with several Matrix tables. We proposed α_i, β_i judgement factor, random fluctuation factor, T_{AB} replacement complementary elasticity index, and constructed planting planning based on a nonlinear 0-1 integer planning model.

Keywords: Nonlinear 0-1 Integer Programming, Genetic algorithm, Crop Planting Optimization, Agricultural Optimization Model.

1. Introduction

Agricultural planting in China's rural economic system occupies a pivotal position, as one of the direct sources of rural economy, its development is directly related to the prosperity and stability of the rural areas. With the continuous evolution of the times how to scientifically and reasonably plan the field planting programme, and then achieve significant improvements in production efficiency and planting risk effectively reduce the urgent needs of the current agricultural field in-depth research and solutions [1-2]. This is not only related to the economic benefits and quality of life improvement of individual farmers, but also the key to promote the whole rural economy to achieve sustainable, high-quality development, as well as to ensure national food security and ecological balance. Currently planning models are widely used in many fields, and in 2019 a scholar proposed Development of a model using matter element, AHP and GIS techniques to assess the suitability of land for agriculture [3]. In 2020 based on the general context of COVID-19, some scholars proposed the need and direction of planning class models for transport planning adjustment [4]. In 2021 some scholars proposed spatial planning zoning based on land type map [5]. In 2022, a scholar used a multi-objective optimization model for planting and harvesting planning of medicinal herbs in terms of supply chain costs, concentration of plant molecules, and farmers' perceptions of economic fairness [2], and in the same year, a scholar constructed a new model to solve the problem of labour force planning for airlines [6]. In 2023, a scholar used a hierarchical planning decision model based on the concept of stratification for the management of flood risk [7]. In 2024, an academic used ORA-constrained planning decision model to assess the reasonableness of treatment [8]. In the same year, an academic also raised the problem of scheduling of terraced hydroelectric power plants [9], and an academic explored the impact of the status of low- and middle-income households on housing planning [10]. The analysis of the last five years of 2019-2024 reveals that there is a significant lack of planning for the cultivation of agricultural crops on farmland based on maximum profit under the influence of multiple factors. In this thesis, the nonlinear 0-1 integer planning can be used to solve the nonlinear relationship between the problem of whether crops are planted or not and multiple factors.

We have three research questions (RQs):

RQ1: How do you arrange and combine different crops and different plots?

RQ2: How do you take into account the impact of a variety of factors such as expected sales of produce, acreage, growing costs, etc.?

RQ3: How can substitutability and complementarity between crops be considered?

Based on these issues, the main contribution of this thesis:

1. The objective function is established with the goal of maximum profit, and a nonlinear 0-1 integer programming model using α_i and β_i judgement factor and random fluctuation factor is proposed.

2. New ideas were proposed to visualise the data by treating a plot that is capable of planting a second season as a new plot and correlating the plot with the crop and its average sales price at that plot.

3. T_{AB} definition of the elasticity of substitution and complementarity indicator is developed, which takes into account the impact of substitution and complementarity between different crops from the perspective of the commodity economy.

2. Problem analysis and modeling

2.1. Description of the Dataset

The dataset we used is the tabular data in the Annex of Question C of the China National University Student Mathematical Modeling Competition 2024, which is available at http://cumcm--cnki--net--https.cnki.mdjsf.utuvpn.utuedu.com:9000/cumcm/Login/LoginIndex website for access. The dataset consists of two tables, sheet1 of schedule 1 is the existing cultivated land in the villages, which contains the plot number, plot type, plot area and relevant description; sheet2 of schedule 1 is the crops planted in the villages, which contains the crop number, crop name, crop type, cultivated land and the description; and sheet1 of schedule 2 is the crops planted in the year 2023, which includes the planted plot, crop number, crop name, crop type, acreage planted, and planting season; and sheet2 of Exhibit 2 focuses on the cost of planting, acreage yield, and unit price of sales for different plots and different seasons of crops in 2023. The dataset includes a total of 41 crops and 55 plots.

2.2. Crop planting planning variables and requirements

According to the growth pattern of crops, each crop should not be planted in the same plot (including greenhouses) in consecutive heavy crops, or yields will be reduced; because soils containing rhizobacteria of legume crops are favorable to the growth of other crops, it is required to plant legume crops at least once in three years for all land in each plot (including greenhouses) starting in 2023.

Based on experience, the expected future annual sales volume of crops varies by about ±5% relative to 2023; the acreage yield of crops varies by ±10% per year; and the cost of growing crops increases by about 5% per year on average. Grain prices are stable; vegetable prices are increasing, averaging about 5 percent per year. The sales price of edible mushrooms is stable and decreasing, and can decrease by about 1% to 5% per year, especially the sales price of morel mushrooms decreases by 5% per year.

There may be a certain degree of substitutability and complementarity between various crops, and a certain correlation between the expected sales volume and the sales price and planting cost. Crops grown each season are sold in the current season. If the total production of a crop per season exceeds the corresponding expected sales volume, the excess is not sold, resulting in wastage.

2.3. Pretreatment:

First check the Schedule I and Schedule II documents separately to make sure the data are correct. The number of plots was expanded from 54 to 82 by treating the plots capable of planting the second season as a new plot. Secondly, based on the modeling requirements, the data were extracted from the annexes and seven (41 crops, 82 plots) matrices on crop production and selling price tables for 2023 and on plot area, average selling price, expected sales volume for 2023, cost of cultivation per unit acre of crops in different plots, pulses, crop yield per acre in different plots, and table of crops to be planted in different plots for 2023 were created and stored separately in different Sheet tables.

Based on four indicators of expected crop sales volume change, mu yield, planting cost, sales price, this paper establishes seven stochastic fluctuation factors. And based on the change interval and law of stochastic volatility factor, Matlab software was used to get the random numbers of the seven stochastic volatility factors in the seven years from 2024 to 2030 based on normal distribution. And the stochastic volatility factor matrix of the four indicators was established.

2.4. Genetic Algorithm Based Modeling of Nonlinear 0-1 Integer Programming.

Step.1 Establishment of the objective function

The objective function is the net profit gained from the cultivation of the rural area in the current year's plot. The net profit is the sum of the net profits from different plots of different or the same crop, as in equation.

$$\max R = \max \sum_{i=1}^{41}\left(\alpha_i \sum_{j=1}^{82} x_{ij} \times S_{ij} \times A_{1j} \times O_{ij} + \beta_i \sum_{j=1}^{82} Y_{ij} \times S_{ij} - \sum_{j=1}^{82} x_{ij} \times P_{ij} \times A_{1j}\right) \quad (1)$$

Where, if x_{ij} is the ith crop planted in the jth plot is 1; if vice versa, it is 0; α_i, β_i is the current year's production of the ith category of crops whether to exceed the expected sales volume in 2023; O_{ij} is the production of the ith category of crops in the jth plot; A_{1i} is the actual acreage planted in the jth plot; S_{ij} is the average selling price of the ith crop in the jth plot; Y_{ij} is the production of the ith crop in the jth plot in 2023; and P_{ij} is the cost of cultivation of crop type i in plot j.

Step.2 Determination of constraints

(1) Constraints on 0-1 decision variables

The coefficient is 1 if a particular plot is assigned to grow a particular crop, and 0 if the opposite is true.

$$x_{ij} = \begin{cases} 1, & \text{Assignment of plot j for crop type i} \\ 0, & \text{opposite} \end{cases} \quad (2)$$

(2) Area constraints

To prevent the model calculations from yielding that the actual planted area of a plot is greater than the actual usable area of a plot. We have constrained the area. A_{1j} is the actual used planted area and A_j is the actual usable planted area.

$$A_{1j} \le A_j \quad (3)$$

(3) Legume cultivation constraints

Since the topic requires that beans be planted at least once in three years, this paper defines bean constraints. B_{1j} is the bean 0-1 constraint. B_{1j}' is the previous year factor and B_{1j}'' is the previous two years factor.

$$B_{1j}=\begin{cases}1, & \text{Assign plot j to plant beans;}\\ 0, & \text{opposite}\end{cases}$$
$$3\geq B_{1j}+B_{1j}'+B_{1j}''\geq 1 \tag{4}$$

(4) No continuous cropping constraints

Crops like corn and other crops continuous heavy cropping will lead to pests and diseases home, crop yield reduction, so the title requires not continuous heavy cropping, requires a reasonable crop rotation and crop change, this paper makes the following constraints. x_{ij}' is the assignment coefficient of the previous year.

$$0\leq x_{ij}+x_{ij}''\leq 1 \tag{5}$$

(5) Constraints on Production and Expected Sales Volume

Since the relationship between the yield and the expected sales volume of a certain crop affects the solution of the objective function, two judgment factors α_i,β_i are proposed to constrain the relationship between the yield and the expected sales volume.

$$\begin{cases}(\alpha_i-\beta_i)\left(\sum_{j=1}^{82}x_{ij}\times A_{ij}\times O_{ij}-\sum_{j=1}^{82}Y_{ij}\right)\leq 0\\ \alpha_i+\beta_i=1\end{cases}$$
$$\alpha_i=\begin{cases}0\\1\end{cases},\alpha_i\in Z \tag{6}$$
$$\beta_i=\begin{cases}0\\1\end{cases},\beta_i\in Z$$

(6) Crop and plantable plot constraints

As a result of solving using the model, this paper finds that crops appear in plot types that cannot be planted. To ensure that crops only appear in the emergent plots, constraints using 0-1 assignment coefficients are required.

$$\begin{cases}\sum_{i=1}^{15}\sum_{j=27}^{82}x_{ij}=0, & \text{Constraints on food crops;}\\ \sum_{i=17}^{34}\sum_{j=1}^{26}x_{ij}=0,\sum_{i=17}^{34}\sum_{j=55}^{78}x_{ij}=0, & \text{Constraints on vegetable crops;}\\ \sum_{i=35}^{37}\sum_{j=1}^{54}x_{ij}=0,\sum_{i=35}^{37}\sum_{j=63}^{82}x_{ij}=0, & \text{Restrictions on vegetables that can only be planted in the second season;}\\ \sum_{i=38}^{41}\sum_{j=1}^{62}x_{ij}=0,\sum_{i=38}^{41}\sum_{j=79}^{82}x_{ij}=0, & \text{Constraints on mycorrhizal crops;}\\ \sum_{j=1}^{26}x_{16j}=0,\sum_{j=34}^{82}x_{16j}=0, & \text{Constraints on rice}\end{cases} \tag{7}$$

The constraint on grain is to ensure that it can only be grown in three types of plots, A, B, and C; the constraint on vegetables is to ensure that they can be grown in the first seasons of D and E and in both seasons of F; the third constraint is to ensure that cabbage and turnip crops can be grown in the second season of D; the constraint on mushrooms is to ensure that they can be grown in the second season of E; and the constraint on rice is to ensure that it is always grown in the irrigated land D.

Step.3 Nonlinear 0-1 integer planning model

By integrating the above constraints, a nonlinear 0-1 integer planning model is derived as shown in Equation (1.8). When the current year's output is higher than the expected sales volume, $\alpha_i = 0, \beta_i = 1$, the maximum net profit of the planting strategy after the production waste can be calculated; if the current year's output is less than the expected sales volume, the maximum net profit of the planting strategy that is not wasted can be calculated.

$$\max R = \max \sum_{i=1}^{41} \left(\alpha_i \sum_{j=1}^{82} x_{ij} \times S_{ij} \times A_{1j} \times O_{ij} + \beta_i \sum_{j=1}^{82} Y_{ij} \times S_{ij} - \sum_{j=1}^{82} x_{ij} \times P_{ij} \times A_{1j} \right)$$

$$s.t \begin{cases} A_{1j} \le A_j; \\ 3 \ge B_{ij} + B_{ij}' + B_{ij}'' \ge 1; \\ 0 \le x_{ij} + x_{ij}'' \le 1; \\ \left(\alpha_i - \beta_i\right) \left(\sum_{j=1}^{82} x_{ij} \times A_{ij} \times O_{ij} - \sum_{j=1}^{82} Y_{ij} \right) \le 0 \\ \alpha_i + \beta_i = 1 \\ \sum_{i=1}^{15} \sum_{j=27}^{82} x_{ij} = 0; \\ \sum_{i=17}^{34} \sum_{j=1}^{26} x_{ij} = 0, \sum_{i=17}^{34} \sum_{j=55}^{78} x_{ij} = 0; \\ \sum_{i=35}^{37} \sum_{j=1}^{54} x_{ij} = 0, \sum_{i=35}^{37} \sum_{j=63}^{82} x_{ij} = 0; \\ \sum_{i=38}^{41} \sum_{j=1}^{62} x_{ij} = 0, \sum_{i=38}^{41} \sum_{j=79}^{82} x_{ij} = 0; \\ \sum_{j=1}^{26} x_{16j} = 0, \sum_{j=34}^{82} x_{16j} = 0 \end{cases} \tag{8}$$

Step.4 Genetic algorithm optimization model

In this paper, we first choose the fitness function in the genetic algorithm, use the binary representation of the variable values, which are organized into "chromosome" strings, initialize the number of populations, the number of iterations K = 80, and the number of populations is 10; through the way of roulette to select the best individuals, i.e., the higher the fitness of the individual, the higher the probability of being selected in the roulette wheel, the more likely that the individual can be saved to the next generation. preserved to the next generation. Through continuous iteration to finally find the best value, that is, the best planting program for that year's crop.

Step.5 Changes to the model under the second sub question

(1) Stochastic fluctuations in expected sales volumes

1. Wheat and corn

$$Y_{ij} = Y_{ij}' \times \xi_{it}^{SY} \tag{9}$$

$i = 6, 7$; Expected sales of wheat and corn are expected to grow at an average annual rate of between (5% and 10%) relative to the previous year. Y_{ij} is the current year's advance sales, and Y_{ij}' is the previous year's advance sales.

2. Other crops (except wheat and corn)

$$Y_{ij} = Y_{ij}' \times \xi_{it}^{Y} \tag{10}$$

$i \neq 6,7$ Expected sales of other crops fluctuate between (-5% to 5%) when compared to expected sales in 2023.

(2) Random fluctuations in acreage

$$O_{ij} = O_{ij}' \times \xi_{it}^{O} \tag{11}$$

Due to a number of factors, the current year's acreage will fluctuate between (-10% to 10%) relative to the previous year.

(3) Random fluctuations in planting costs

$$P_{ij} = P_{ij}' \times \xi_{it}^{P} \tag{12}$$

Subject to market conditions, the current year's growing costs will increase by 5% relative to the previous year.

(4) Random fluctuations in selling prices

1. Vegetables

$$S_{ij} = S_{ij}' \times \xi_{it}^{SS} \tag{13}$$

$i = 17,18,...,37$; Sales prices for vegetable crops increased by an average of 5 percent relative to the previous year.

2. Edible mushrooms (except morel mushrooms)

$$S_{ij} = S_{ij}' \times \xi_{it}^{SJ} \tag{14}$$

$i = 38,39,40$; The sales price of edible mushrooms is on a relative downward trend, declining approximately (1% to 5%) per year relative to the previous year.

3. Morel mushrooms

$$S_{ij} = S_{ij}' \times \xi_{it}^{SY} \tag{15}$$

$i = 41$; The sales price of morel mushrooms decreased by 5% per year relative to the previous year.

2.5. Improvements to the model considering complementarities and substitutions

First of all, this paper believes that substitutability refers to goods that can be substituted for each other in terms of use value, when the price of a certain type of goods rises, its expected sales volume will inevitably decrease, while its corresponding substitutes expected sales volume will rise. Secondly, this paper argues that complementary goods refers to the existence of a certain consumption relationship between the two items, when a change in the expected sales volume of one item will inevitably cause a synchronized change in the expected sales volume of the other item.

The substitution complementarity elasticity formula is a concept that measures the degree of substitution or complementarity between two items. It is defined as the percentage change in the expected sales volume ratio of an item caused by a one percent change in the price ratio of the item. The formula is obtained by referring to the reference formula and modified as follows.

$$T_{AB} = \frac{\left(dx_A / x_A\right)}{\left(dp_A / p_A\right)} \times \frac{\left(dp_B / p_B\right)}{\left(dx_B / x_B\right)} \tag{16}$$

T_{AB} is an indicator of the elasticity of substitution and complementarity of items A and B. When it is closer to 1, the degree of substitution between the two items is higher; when it is closer to -1, the degree of complementarity between the two items is higher; 0 means neither substitutes nor complements; 1 means that there is a perfect substitution between A and B; and -1 means that there is a perfect complementarity between A and B. dx/x is the rate of change in the quantity demanded of the good; dp/p is the rate of change in the price of the good. Define the following equation.

$$\sum_{j=1}^{82} Y_{Aj}^{T} = \sum_{j=1}^{82} Y_{Aj}' \times \left(1 + T_{AB} \times (S_{Bj} - S_{Bj}')\right) \tag{17}$$

A and B are subscripts for different types of crops. $\sum_{j=1}^{82} Y_{Aj}^{T}$ is the expected sales volume of crop type A in the current year; $\sum_{j=1}^{82} Y_{Aj}'$ is the expected sales volume of crop type A in the previous year; S_{Bj} is the sales price of crop type B in the jth plot in the current year; S_{Bj}' is the sales price of crop type B in the jth plot in the previous year.

For simplicity of modeling, items A and B are not treated as mutual substitutes or complements when the substitutability and complementarity between them is too weak. This paper provides for treating A and B as mutual substitutes when $T_{AB} \in [0.5, 1]$; When $T_{AB} \in [-1, -0.5]$ treat A and B as complementary to each other. When $T_{AB} \notin [-1, 1]$, it has no mathematical meaning; Since T_{AB}, T_{BA} have the same mathematical meaning, only the absolute value of $|1|$ is retained as the complementary coefficient of substitution for A and B items.

In this paper, crops are defined into three main categories, grains, vegetables, and mushrooms. There may be some relationship between the expected sales volume of these categories and the sales price, the selling price and the cost of cultivation, defined in the following equation.

$$\sum_{j=1}^{82} Y_{ij} = \sum_{j=1}^{82} Y_{ij}^{T} + \sum_{j=1}^{82} Y_{ij}' \times r_i \times \frac{S_{ij} - S_{ij}'}{S_{ij}'} \tag{18}$$

$\sum_{j=1}^{82} Y_{ij}$ is the expected sales volume of crop i for the current year; $\sum_{j=1}^{82} Y_{ij}'$ is the expected sales volume of crop i in the previous year; $\sum_{j=1}^{82} Y_{ij}^{T}$ is the expected sales volume of crop i in the current year that has been subjected to the replacement complementarity elasticity formula; S_{ij} is the average sales price of crop i in plot j in the current year; S_{ij}' is the average sales price of crop i in the previous year in plot j.

$$S_{ij} = S_{ij}' \times \left(1 + r_i \times \frac{\left(P_{ij} - P_{ij}'\right)}{P_{ij}'}\right) \tag{19}$$

P_{ij} is the cost of growing the ith crop in the jth plot in the current year; P_{ij}' is the cost of growing the i-th crop in the j-th plot in the previous year.

The data processing will finally get the rate of change in every two years of the six-year group from 2024 to 2030, in order to reduce the influence of random numbers and unknown factors. In this paper, after finding the mean value of the data in these six years, we solve the replacement elasticity coefficients of various crops according to the defined formula, and get the replacement elasticity coefficients of complementary matrix.

3. Results and discussion

3.1. Convergence and Global Search of Planting models

Due to the large amount of data of the best planting scheme from 2024 to 2030, this paper only shows the solution and analysis of the 2025 model. As shown in Figure 1, the convergence speed and global search speed of genetic algorithm are faster in the early and middle stages, which indicates that the use of genetic algorithm to optimize the model greatly saves the calculation time and improves the efficiency of finding the best crop planting strategy of the year.

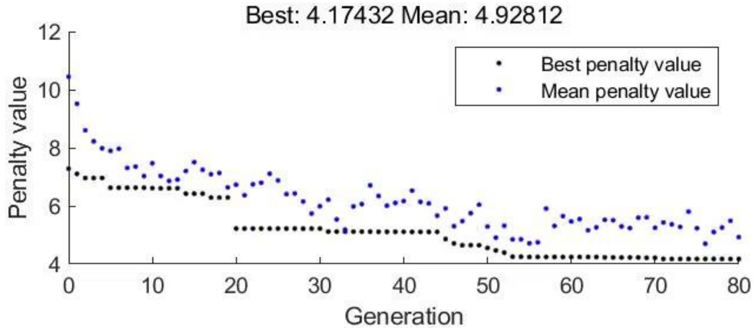

Figure 1. Change in fitness

In order to optimize the planting strategy and realize the sustainable development of rural economy, the model obtains the best planting plan of this village from 2024 to 2030 as shown in Figure 2. Due to space reasons, only the best planting plan of 2025 is shown. The yellow label indicates planting crops, the green label does not plant crops, where the behavioral crop number is listed as the plot number.

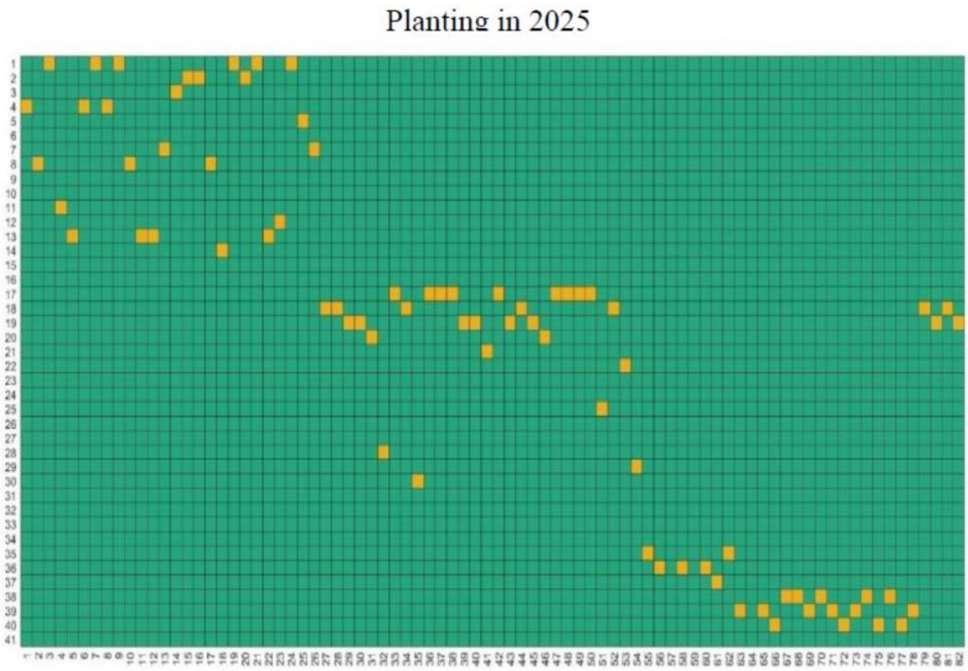

Figure 2. The best planting plan in 2025

By using the support data, it can be obtained that the net profit of the crop planting program in 2023 is 5915,000 yuan. Without considering the reduction of production and other factors, if the program is used to 2024 ~2030, a total profit of 41,405,000 yuan can be obtained. As shown in Figure 3, the model shows that the profit of the scheme from 2024 to 2030 is 36016600 yuan. Compared with the 2023 planting scheme, the planting scheme solved by the seven years model from 2024 to 2030 has a profit of 5388400 Yuan less, with a decline rate of 13.01%, but it ensures the sustainable development of the countryside, and the planting operation is carried out according to local conditions. Its profit reduction is within an acceptable range.

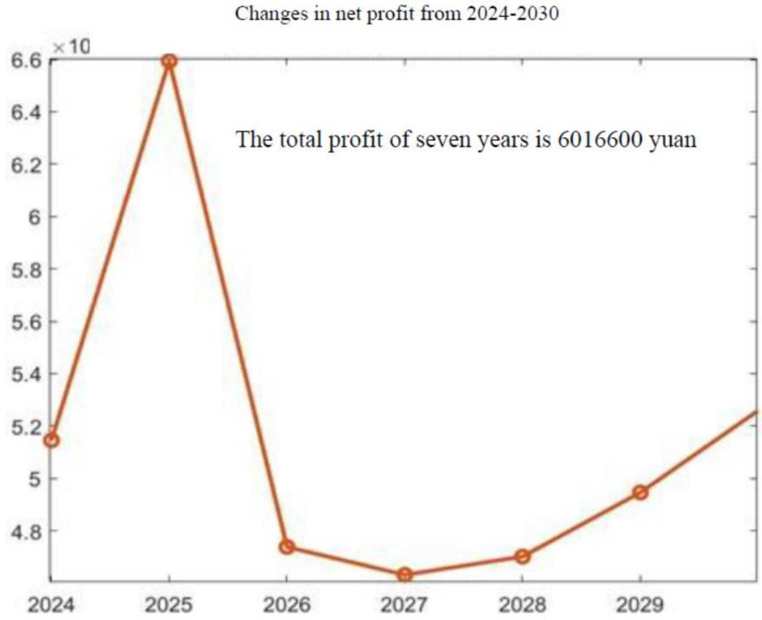

Figure 3. Net plantation profit from 2024 to 2030

3.2. Comparative analysis of total profit and risk of planting plan

Matlab software is used to obtain the random numbers of seven fluctuation factors from 2024 to 2030 based on the normal distribution, which is used to simulate the planting uncertainty caused by multiple factors and the agricultural planting risk caused by it. As shown in Table 1, is the random fluctuation factor of the expected sales of wheat and corn generated by Matlab software from 2024 to 2030.

Table 1. Stochastic volatility factors of expected sales

Year	(wheat) value	(corn) value
2024	1.088821	1.1
2025	1.163206	1.176566
2026	1.23605	1.272714
2027	1.335353	1.341062
2028	1.448994	1.433641
2029	1.531076	1.577005
2030	1.684184	1.709102

After updating the data in the model through the random fluctuation factor in the same year, the model was run to simulate the uncertainty and planting risk caused by various factors in agricultural planting, and the best planting plan from 2024 to 2030 was obtained. Due to the space reason, only the best planting plan in 2028 was shown. The yellow label indicates planting crops, the green label does not plant crops, where the behavioral crop number is listed as the plot number. This is shown in Figure 4.

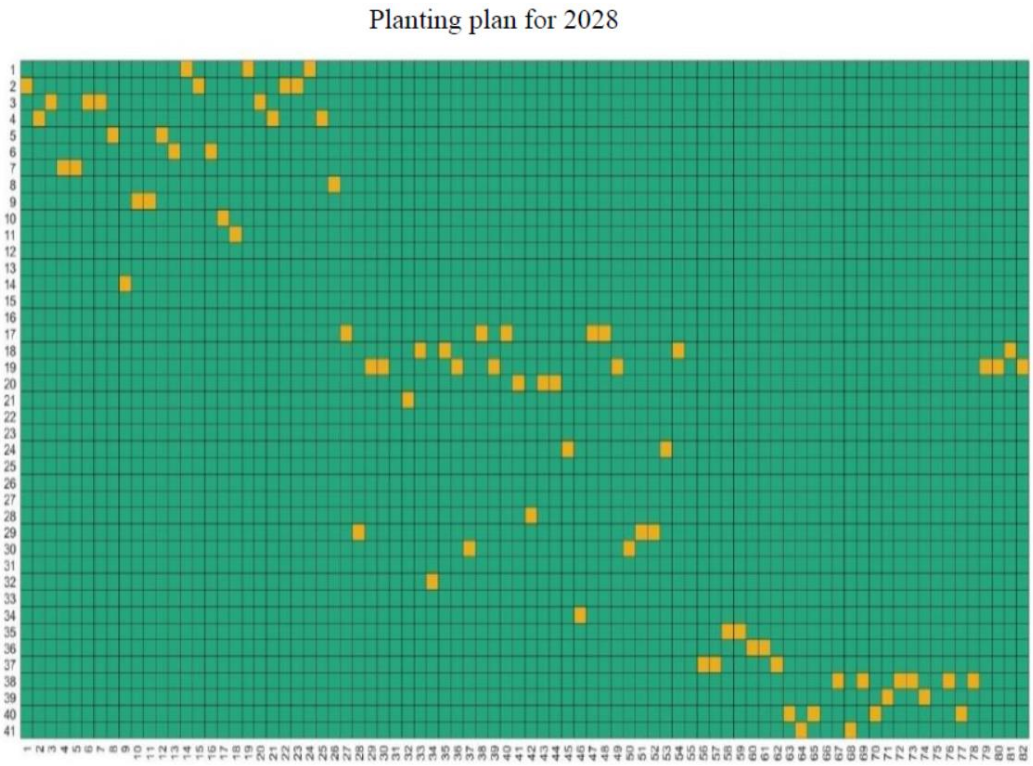

Figure 4. The best planting plan in 2025

3.3. Evaluation of standard deviation and variance

This article holds that the correlations between expected sales volume and sales price, as well as between sales price and planting cost, among crops of the same category exhibit certain similarities. Therefore, the 41 types of crops are classified into three categories: grains, vegetables, and fungi. Pearson correlation coefficient analysis was conducted separately for the three categories, and the results are shown in Table 2.

Table 2. Table of correlation coefficients

Type / Relationship	Expected sales volume and sales price	Sales price and planting cost
Food products	$r_i = -0.285, i = 1,\dots,16$ There is a negative correlation	$r_i' = -0.220, i = 1,\dots,16$ There is a negative correlation
Vegetables and vegetables	$r_i = -0.502, i = 17,\dots,37$ There is a negative correlation	$r_i' = 0.338, i = 17,\dots,37$ There is a positive correlation
fungi	$r_i = -0.692, i = 38,\dots,41$ There is a negative correlation	$r_i' = 0.267, i = 38,\dots,41$ There is a positive correlation

As shown in Figure 5, after comprehensive consideration, the seven-year net profit of the planting strategy from 2024 to 2030 is 40423790 yuan. Without comprehensive consideration of the planting plan from 2024 to 2030, the net profit of the seven years was 40965,300 yuan, and the total profit after comprehensive consideration decreased by 1.32%. And the standard deviation of the net profit for the next seven years is $\sqrt{\sigma} = 0.37565$; And the net profit variance of the seven years after the comprehensive consideration is $\sqrt{\sigma} = 0.53883$.

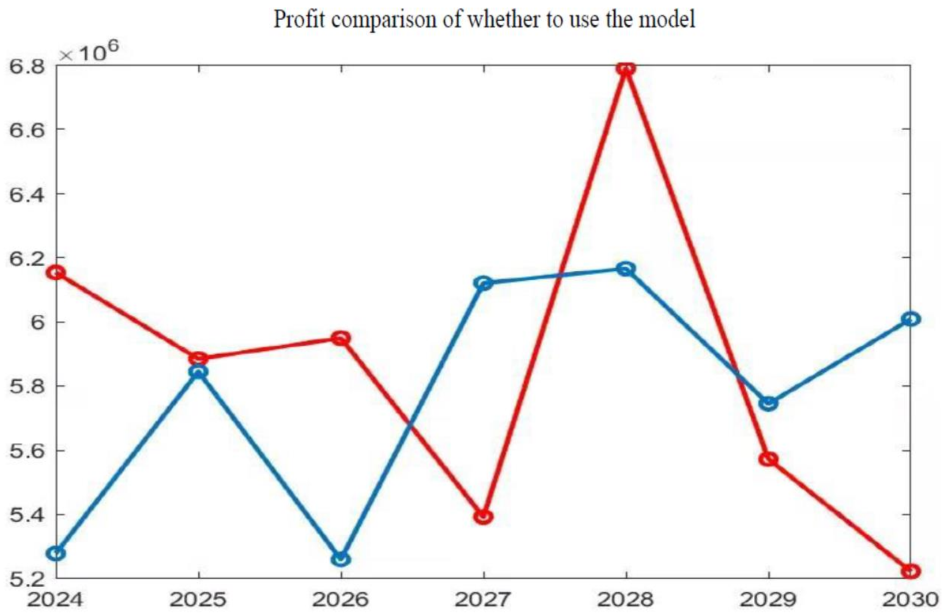

Figure 5. Profit comparison of whether to use the model
(Red is used but blue is not)

4. Conclusion

Multiple constraints such as arable land types, crop production patterns, farming operations and field management, and multiple uncertainties such as expected crop sales and planting costs provide the basis for the planning of planting scenarios and the modelling of maximum planting profit in rural areas in the mountainous regions of North China. However, the traditional planning model cannot withstand so many constraints and uncertainties, and the planning effect on this type of problem is not good. In this paper, the maximum planting profit model is established by using the nonlinear 0-1 integer planning model, which makes full use of the characteristics of 0-1 integer planning applicable to complex constraints, and iterates the optimal solution using genetic algorithm. It provides a basis for modelling the scenario of multiple constraints and multiple uncertainties, and has certain practical application value. The model currently has problems such as high computational volume and low accuracy, and other algorithms will be introduced in the future to further reduce the computational volume and improve the accuracy.

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