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# Study on Crop Planting Strategies in the Context of Sustainable Agricultural Development

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**Abstract.** In recent years, agricultural production has been showing a new trend of structural optimization and quality improvement with the economic growth. However, crop rotation involves a complex soil-crop-environment system, and different agricultural conditions and planting habits vary from region to region. Therefore, it is a challenge for farmers and management departments to formulate a reasonable crop rotation plan. For the problem of planting strategies, this study established a single-objective optimization model with the maximum stable profit, which solved the optimal planting scheme for the next 7 years of crops under the conditions of unsold waste and discounted sales. It also established a stochastic dynamic optimization model with the maximum uncertain profit, which solved the planting strategy problem under uncertain conditions. It has significant practical significance. The total profits for the next seven years under the scenario of unsold inventory waste and discounted sales are estimated at 11.37 million yuan and 23.77 million yuan.

**Keywords:** Single-objective planning model; Stochastic planning model; Planting strategy; Particle Swarm Optimization algorithm.

## 1. Introduction

With the rapid development of China's economy and the improvement of people's living standards, agricultural production is gradually showing a new trend of structure optimization and quality improvement. As the basic industry of national food security, the sustainable development of agriculture is very important. As a scientific agricultural production method, cultivated land rotation can not only improve soil fertility and soil structure, but also adjust crop planting structure, bringing significant ecological and economic benefits [1]. However, cultivated land rotation involves a complex soil-crop-environment system, coupled with different agricultural conditions and planting habits in different regions [2], making a reasonable rotation plan has become a challenge for farmers and management departments. How to balance short-term economic benefits and long-term ecological benefits, formulate rotation policies adapted to different regions and crops, and evaluate the long-term effects of rotation are all issues that need to be studied [3].

Farmers usually consider both risk and non-risk factors when deciding on planting methods. Non-risk factor studies show that farmers tend to prefer crop rotation and diversification in order to maximize land output due to limited means of production, limited economic opportunities and market size, and decentralized production. If these non-risk factors become the main drivers of agricultural production mode selection, then policy-based agricultural insurance may not reduce the diversity of agricultural cultivation, but may enhance the diversification trend, and may even make diversified cultivation the norm. This can lead farmers to fall into inefficient farming patterns that are difficult to shift, which is detrimental to improving the efficiency of overall agricultural production.

This paper focuses on the optimization of crop planting strategies in a village in the mountainous area of North China. The rural climate is relatively cold, most of the farmland can only grow one season of crops per year, the existing open farmland 1201 mu, divided into 34 different plots, including flat dry land, terraces, slopes and irrigated land. Different plots are suitable for different crops, one season per year; Irrigated land is suitable for one season of rice or two seasons of vegetables. The village also has 16 ordinary greenhouses and 4 smart greenhouses, each with an area of 0.6 mu, ordinary greenhouses are suitable for planting one season of vegetables and one season of edible fungi, and smart greenhouses can grow two seasons of vegetables. In order to make full use of limited cultivated land resources and optimize crop planting strategy, factors such as crop planting cycle, market demand and soil fertility must be considered comprehensively. In this study, the optimal crop planting plan from 2024 to 2030 was analyzed through mathematical modeling. Firstly, a single-objective programming model with maximum profit was established in a stable state to solve the problem of optimal crop planting plan in the next 7 years under the two conditions of slow sale and waste and discount sale. Secondly, a stochastic programming model with maximum uncertain profit was established to solve the problem of planting strategy under uncertain conditions.

This study has the following innovative points: First, the model comprehensively considers many factors such as planting area, crop types, cultivated land restrictions, crop rotation requirements, etc. The model can fully reflect the actual constraints and demands in agricultural production. This multi-dimensional consideration enables the model to weigh the mutual influence of different variables in the decision-making process and avoid the limitations caused by a single factor, thus improving the efficiency of resource utilization. Secondly, by introducing uncertainty analysis, the model can adapt to market and environment changes. The model can simulate and quantify the effects of uncertain factors such as price fluctuations and climate change. In the modeling process, optimization problems under different scenarios are constructed to improve the adaptability of the model to realistic complex situations, so as to choose a more robust planting plan, so as to effectively deal with potential risks and uncertainties.

## 2. Literature review

At present, the academic circle has carried out extensive research and discussion on the problem of optimizing planting. Feng Guangliang [4] studied the agricultural planting structure configuration in the lower reaches of Tarim River based on the two-layer planting optimization model, and calculated the planting structure optimization in the study area under the conditions of single-layer planning and double-layer planning. The results show that the two-layer optimization scheme is superior to the single-layer optimization scheme and the current scheme. By using Penman-Monteith model and path analysis, Wu Menghan [5] analyzed the change of water requirement of wheat, corn and cotton during the growing period and its relationship with meteorological factors in Shacheh irrigation district. Further, from the three angles of agricultural ecological benefit, economic benefit and irrigation water consumption, combined with the national 14th Five-Year Plan and local agricultural development policies, a multi-objective comprehensive optimization model was established to adjust and optimize the planting structure of crops in irrigated areas. Starting from the constraint of irrigation water use efficiency, Li Mingliang [6] studied the optimization of agricultural planting structure in irrigated areas, explored the optimal evaluation model of irrigation water use efficiency, analyzed its driving mechanism, and initially explored its adaptive regulation strategy. With the comprehensive goal of maximizing economic, social, ecological and water resources benefits, Li Yanbin et al. [7] introduced inertial weight attenuation and particle variation strategies to establish a multi-objective agricultural planting structure optimization model based on improved particle swarm optimization algorithm. To sum up, there is still little research on how to optimize under uncertain conditions.

## 3. Methods and data

### 3.1. Beyond the unmarketable planting planning model

### 3.1.1. Establishment of objective function.

Taking the profit maximization of farmers as the objective function, it is required to increase the overall income of farmers as much as possible by rationally formulating crop planting plans between 2024 and 2030, taking into account the unsalable portion of overproduction.

$$\max Z=\sum_{t=1}^{7}\sum_{i=1}^{82}\sum_{j=1}^{41}\left[Q_{tij}\cdot P_{tj}\cdot Y_{tij}-X_{ij}\cdot C_{ij}\right] \tag{1}$$

Where $P_{tj}$ is the sales price of the j crop in the future year t, which is treated as a decision variable in this paper, so that its value is within the statistical price in 2023. $X_{tij}$ is the number of acres planted by the j crop in the Class i plot in the year t, $Y_{ij}$ is the mu yield planted by the j crop in the class i plot in the year t, and $Q_{tij}$ represents the demand for the j crop planted in the class i plot in the year T. $C_{ij}$ is the planting cost of planting the j crop in the Class i plot in year t.

### 3.1.2. Determination of constraints.

To ensure that each crop is planted in the corresponding position, this paper makes the following constraints on the rationality of planting:

$$\begin{cases} X_{tij}\geq 0, i=1,2,3...26; j=1,2,3...15 \\ X_{tij}\geq 0, i=27,28,29...34; j=16 \\ X_{tij}\geq 0, i=27,28,29...50,79,80,81,82; j=17,18,19...34 \\ X_{tij}\geq 0, i=55,56,57...62; j=35,36,37 \\ X_{tij}\geq 0, i=63,64,65...78; j=38,39,40,41 \\ X_{tij}=0, else \end{cases} \tag{2}$$

Where $X_{tij}$ is the number of acres planted on the type i plot for planting the j crop in the year t. This constraint indicates that, for example, food crops (except rice) can only be planted on flat dry land, terraces and hillsides, and the number of acres planted on food crops can only be greater than or equal to 0 on flat dry land, terraces and hillsides, and cannot be planted on other lands, that is, the number of acres planted must be equal to 0.

Ensure that the total planted area of each plot does not exceed the available arable area:

$$\sum_{j=1}^{41} X_{ij}\leq SA_i \tag{3}$$

Where, $SA_i$ represents the plot area of the i plot, and this constraint ensures that the sum of the planting area of crops on each plot is less than or equal to the total area of the plot.

According to the price elasticity model, there is a certain relationship between the expected sales volume and the selling price:

$$Q_{tj}=b_j-a_j\cdot P_{tj} \tag{4}$$

Where $Q_{tj}$ represents the expected sales volume of crop j in year t, and $a_j$ represents the price elasticity of crop j.

Each crop in the same plot, can not be planted continuously, otherwise it will reduce production:

$$\begin{gathered} X_{t+1ij}=0; t=0,1,2\cdots 7 \quad , X_{tij}\geq 0 \\ X_{(t+1)ij}=X_{ti(j+28)}=X_{(t+1)i(j+28)}=0; t=0,1,2\cdots 7,\ X_{tij}>0 \end{gathered} \tag{5}$$

Where, t=0 represents the base year 2023, and the no continuous planting constraint should be calculated from the planting of each field in 2023. This constraint means that if the j crop is planted in the i field in the next t year, the crop cannot be planted continuously in the next year. In particular, in the type of plots represented by i in this paper, the same plots in the first and second seasons are represented by two numbers, which helps to simplify the constraints of planting in multiple stages without continuous crossover. However, in view of the special situation that irrigated land can plant rice in a single season or vegetable crops in two seasons every year, this paper adds constraints:

$$\begin{gathered} X_{(t+1)ij} = X_{(t+1)i(j+28)} = 0; t = 0,1,2\cdots 7;\ j = 16; i = 27,28,29\cdots 34, X_{tij} > 0 \\ \forall j, X_{ti(j+28)} = 0 \end{gathered} \tag{6}$$

The above constraints mean that if the irrigated field of the first season is planted with rice, the irrigated field of the second season is planted with rice and cannot be planted with rice, and the next season cannot be planted with rice.

Starting in 2023, all land in each plot (including greenhouses) will be required to plant pulses at least once in three years:

$$\forall j, X_{ijt} + X_{ij(t+1)} + X_{ij(t+2)} > 0,\ j = 1,2,3,4,5,17,18,19; t = 0,1,2,3\cdots 7 \tag{7}$$

The above constraints indicate that the area of beans planted in three consecutive years must be greater than 0, that is, the pair means that beans must be planted in three years.

The indicators describing the concentration of cultivated crops are defined above, and thresholds for different types of crops are determined based on 2023 data:

$$CV_j = \begin{cases} 1.959,\ j \in \text{foodstuff} \\ 2.204,\ \ j \in \text{vegetable} \\ 2.449,\ \ j \in \text{Edible fungi} \end{cases} \tag{8}$$

In order to facilitate management, the planting area of each crop in a single plot (including greenhouses) should not be too small, the minimum planting area is calculated above:

$$X_{tij} \geq X_{ijleast} \tag{9}$$

$X_{ijleast}$ indicates the minimum number of acres planted by the JTH crop in the i land, and this constraint indicates that the planting area of the JTH crop in the i land must be greater than the threshold of the minimum number of acres. This constraint also restricts the whole planting of rice, a special crop.

### 3.1.3. The establishment of planning model.

$$\max Z = \sum_{t=1}^{7}\sum_{i=1}^{82}\sum_{j=1}^{41}\left[Q_{tij} \cdot P_{tj} \cdot Y_{tij} - X_{ij} \cdot C_{ij}\right]$$

$$s.t. \begin{cases} \sum_{j=1}^{41} X_{ij} \leq \sum_{j=1}^{41} X_{ij} \leq SA_i \\ \min(PP_{0j}) \leq P_{tj} \leq \max(PP_{0j}) \\ Q_{tj} = b_j - a_j \cdot P_{tj} \\ X_{t+1ij} = 0; t = 0,1,2\cdots 7, X_{tij} \geq 0 \\ X_{(t+1)ij} = X_{ti(j+28)} = X_{(t+1)i(j+28)} = 0; t = 0,1,2\cdots 7 \text{且} X_{tij} \geq 0 \\ X_{(t+1)ij} = X_{(t+1)i(j+28)} = 0; t = 0,1,2\cdots 7;\ j = 16; i = 27,28,29\cdots 34, X_{tij} \geq 0 \\ \forall j, X_{ti(j+28)} = 0 \\ \forall j, X_{ijt} + X_{ij(t+1)} + X_{ij(t+2)} > 0,\ j = 1,2,3,4,5,17,18,19; t = 0,1,2,3\cdots 7 \\ CV_j = \begin{cases} 1.959,\ j \in \text{foodstuff} \\ 2.204,\ \ j \in \text{vegetable} \\ 2.449,\ \ j \in \text{Edible fungi} \end{cases} \end{cases} \tag{10}$$

### 3.2. Beyond the price reduction planting planning model

Under the "partially unsalable" scheme, when total crop production exceeds expected sales, the excess will be sold at a 50 percent discount to the 2023 sales price. In this way, to reduce the loss caused by excess production, help farmers recover a certain cost, reduce losses, theoretically speaking, the profit of this program should be slightly larger than the profit beyond the unsalable type.

#### 3.2.1. Establishment of objective function.

Taking the profit maximization of farmers as the objective function, it is required to increase the overall income of farmers as much as possible by rationally formulating crop planting plans and considering the price reduction of the over-production part during the period of 2024 to 2030.

$$\max Z=\sum_{t=1}^{7}\sum_{i=1}^{82}\sum_{j=1}^{41}\left[Q_{tij}\cdot P_{tj}\cdot Y_{tij}+(X_{tij}-Q_{\mathrm{tij}})\cdot P_{tj}\cdot 0.5-X_{tij}\cdot C_{ij}\right] \tag{11}$$

#### 3.2.2. Determination of constraints.

Similarly, this paper establishes the following planning model based on the above analysis:

$$\max Z=\sum_{t=1}^{7}\sum_{i=1}^{82}\sum_{j=1}^{41}\left[Q_{tij}\cdot P_{tj}\cdot Y_{tij}+(X_{tij}-Q_{\mathrm{tij}})\cdot P_{tj}\cdot 0.5-X_{tij}\cdot C_{ij}\right]$$
$$s.t.\begin{cases}\sum_{j=1}^{41}X_{ij}\le SA_i\\ \min(PP_{0j})\le P_{tj}\le\max(PP_{0j})\\ Q_{tj}=b_j-a_j\cdot P_{tj}\\ X_{t+1ij}=0,\ \ t=0,1,2\cdots 7,\ \ X_{tij}\ge 0;\\ X_{(t+1)ij}=X_{ti(j+28)}=X_{(t+1)i(j+28)}=0;t=0,1,2\cdots 7,\ \ X_{tij}\ge 0;\\ X_{(t+1)ij}=X_{(t+1)i(j+28)}=0;t=0,1,2\cdots 7;\ j=16;i=27,28,29\cdots 34,\ \ X_{tij}\ge 0;\\ \forall j,X_{ti(j+28)}=0\\ \forall j,X_{ijt}+X_{ij(t+1)}+X_{ij(t+2)}>0,\ j=1,2,3,4,5,17,18,19;t=0,1,2,3\cdots 7\\ CV_j=\begin{cases}1.959,\ j\in\text{foodstuff}\\ 2.204,\ \ j\in\text{vegetable}\\ 2.449,\ \ j\in\text{Edible fungi}\end{cases}\end{cases} \tag{12}$$

### 3.3. Indefinite factor planting model based on stochastic programming

This topic is to develop the optimal planting plan for the countryside from 2024 to 2030, taking into account the uncertainties of crop sales volume, per mu yield, planting cost and selling price fluctuations. Annual sales of wheat and corn are expected to increase by 5% to 10%, while other crops fluctuate by ±5%. The yield per mu fluctuates by ±10% under the influence of climate, and the planting cost increases by 5% every year. The price of grain crops was stable, the price of vegetables increased by 5% annually, and the price of edible fungi decreased by 1%-5%, of which morels decreased by 5%. These factors need to be integrated into a programme.

#### 3.3.1. Determination of constraints.

In this case, these random variables have a definite range set as a quantity that follows a uniform distribution of fluctuations, and the probability density function f(x) of the uniform distribution is defined as:

$$f(x)=\begin{cases}\dfrac{1}{b-a},a\le x\le b\\ 0,else\end{cases} \tag{13}$$

The undetermined range is set to a quantity that follows a normal distribution fluctuation, and the probability density function f(x) of a uniform distribution is defined as:

$$f(x;\mu,\sigma)=\frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{(x-\mu)^2}{2\sigma^2}} \tag{14}$$

Based on the given information, annual sales of wheat and corn are expected to increase between 5% and 10%. This growth rate can be viewed as a uniform distribution over the interval [0.05, 0.10]:

$$g_{\text{wheat, corn}}(x)\sim U(0.05,0.10) \tag{15}$$

Where, $g_{\text{wheat, corn}}(x)$ is the growth rate of wheat and corn sales.

For other crops, the annual sales volume fluctuates within the range of ±5%, that is, the sales volume changes within the range [−0.05, 0.05], which can be characterized as a uniform distribution over [−0.05, 0.05]:

$$g_{\text{other crops}}(x)\sim U(-0.05,0.05) \tag{16}$$

Where, $g_{\text{other crops}}(x)$ is the volatility of the annual sales volume of other crops.

According to climatic conditions, the fluctuation range of crop yield per mu is ±10%, that is, the fluctuation of yield per mu is within the range of [−0.10, 0.10], which can be characterized as a uniform distribution on [−0.10, 0.10]:

$$y(x)\sim U(-0.10,0.10) \tag{17}$$

Where y (x) is the fluctuation rate of yield per mu.

The average annual growth rate of planting costs is 5%, so it can be assumed that the growth rate of planting costs fluctuates within a small range and follows a normal distribution:

$$y(x)\sim U(-0.10,0.10) \tag{18}$$

Where c is the annual growth rate of planting costs.

The price of vegetable crops is expected to increase by 5% a year, so the price growth rate can be seen as fluctuating in a small range, subject to uniform distribution:

$$p_{\text{vegetable}}(x)\sim N(0.05,0.01) \tag{19}$$

Where $p_{\text{vegetable}}(x)$ is the annual growth rate of vegetable prices

The price decline rate of edible fungi is between 1% and 5%. We can define the rate of change of the price of edible fungi in the range of [−0.05, −0.01], following a uniform distribution:

$$p_{\text{vegetable}}(x)\sim N(0.05,0.01) \tag{20}$$

Where, $p_{\text{fungi}}(x)$ is the annual decline rate of the price of edible fungi

According to literature review, climate factors, market factors, diseases and insect pests and other factors [8] will have an impact on the expected sales volume, per mu yield, planting cost and selling price of crops [9]. In this paper, risk factor α is introduced to adjust the various change rates, and the value range of α is [0.8, 1.2]. This paper uses computer-generated random numbers to simulate the potential planting risks that exist each year.

### 3.3.2. The establishment of planning model.

Based on the above analysis, this paper establishes the following planning model:

$$\max Z = E\left(\sum_{t=1}^{7}\sum_{i=1}^{82}\sum_{j=1}^{41}\left[Q_{tij}\cdot P_{tj}\cdot Y_{tij}+(X_{tij}-Q_{\mathrm{tij}})\cdot P_{tj}\cdot 0.5-X_{tij}\cdot C_{ij}\right]\right)$$

$$s.t.\begin{cases} \sum_{j=1}^{41} X_{ij} \le SA_i \\ \min(PP_{0j}) \le P_{tj} \le \max(PP_{0j}) \\ Q_{tj} = b_j - a_j \cdot P_{tj} \\ ifX_{tij} \ge 0, X_{t+1ij} = 0; t = 0,1,2\cdots 7 \\ ifX_{tij} > 0, X_{(t+1)ij} = X_{ti(j+28)} = X_{(t+1)i(j+28)} = 0; t = 0,1,2\cdots 7 \\ ifX_{tij} > 0, X_{(t+1)ij} = X_{(t+1)i(j+28)} = 0; t = 0,1,2\cdots 7;\ j = 16; i = 27,28,29\cdots 34 \\ \forall j, X_{ti(j+28)} = 0 \\ \forall j, X_{ijt} + X_{ij(t+1)} + X_{ij(t+2)} > 0,\ j = 1,2,3,4,5,17,18,19; t = 0,1,2,3\cdots 7 \\ CV_j = \begin{cases} 1.959,\ j \in \text{foodstuff} \\ 2.204,\ \ j \in \text{vegetable} \\ 2.449,\ \ j \in \text{Edible fungi} \end{cases} \\ \begin{cases} \bar{Q}_{tij} = \int_{-0.1\cdot\alpha}^{0.1\cdot\alpha} Q_{(t-1)ij}\cdot(1+x_1\cdot\alpha)\cdot g(x_1\cdot\alpha)dx_1,\ j = 6,7 \\ \bar{Q}_{tij} = \int_{-0.05\cdot\alpha}^{0.05\cdot\alpha} Q_{tij}\cdot(1+x_2\cdot\alpha)\cdot g(x_2\cdot\alpha)dx_2,\ j \ne 6,7 \\ \bar{P}_{tj} = P_{(t-1)j}\cdot 1.005\cdot\alpha,\ \ \mathrm{j} \in \text{vegetable} \\ \bar{Y}_{tij} = \int_{-0.1\cdot\alpha}^{0.1\cdot\alpha} Y_{tij}\cdot(1+x_4\cdot\alpha)\cdot y\cdot x_4\cdot\alpha dx_4, \\ \bar{C}_{ij} = C_{(t-1)ij}\cdot 1.005\cdot\alpha \end{cases} \end{cases} \tag{21}$$

## 3.4. Data

The data sources of this study are rural crop planting and related statistical data in 2023, including the planting area and land type of existing rural farmland. And the kinds of crops grown in the countryside. The northern mountainous areas have complex terrains and have always been an important area of study for scholars. In addition, some of China's major crop production areas are concentrated in the north, so researching planting strategies for the northern mountainous areas has implications for agricultural planting nationwide [10].

## 4. Results

### 4.1. The solution of unmarketable planting planning model

Particle swarm optimization was used to optimize the planning model and solve the part of 2024 with the following results:

**Table 1.** Calculation Results of Unsalable Planning (First Quarter Section)

| Plot name | Soya beans | Plot name | Mung bean | Plot name | Crawling bean |
|---|---|---|---|---|---|
| A1 | 80 | A2 | 55 | A4 | 72 |
| B4 | 28 | B7 | 55 | A6 | 55 |
| B9 | 50 | B12 | 45 | B6 | 86 |
| C6 | 20 | C5 | 27 | | |

Table 1 shows the calculation results of some grain planning in 2024. Food crops conform to the principle of large-area planting, and large-area centralized planting not only facilitates unified management and improves production efficiency, but is consistent with the planting management scale in 2023. Figure.1 shows the unsalable vegetable data for the next 7 years.

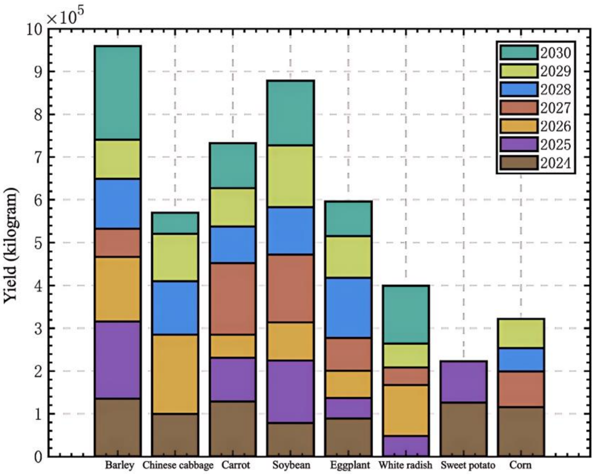

**Figure 1.** Unsalable vegetable data for the next 7 years

This graph shows the unsalable situation of different crops in the unsalable model. The crops with high unsalable quantity are concentrated in some varieties, such as soybeans, barley, radish, etc. In some years, the unsalable situation of some crops is particularly serious. For example, white radish is very significant in 2029 and 2030, and barley is also large in several years. It may be related to the planting structure and consumption changes of that year.

### 4.2. The solution of the planting planning model of excess reduction

In this problem, the solution process of the unmarketable model is followed, and the particle swarm optimization algorithm is used to solve the problem according to the idea of optimizing year by year.

**Table 2.** Calculation Results of promotional Planning (Q1 Part)

| Plot name | Black bean | Plot name | Ormosia bean | Plot name | Mung bean | Plot name | Crawling bean |
|---|---|---|---|---|---|---|---|
| A2 | 55 | B3 | 40 | A1 | 80 | A6 | 55 |
| C4 | 18 | C3 | 15 | B10 | 25 | C5 | 27 |
| | | | | | | C6 | 20 |

Table.2 shows the calculation results of the 2024 grain planting plan, which meets the requirements of large-scale planting. This large area of intensive cultivation helps to unify management, improve production efficiency, and is consistent with the scale of cultivation management in 2023. The following chart shows the data of discounted vegetables for the next 7 years.

Figure.2 shows the discounting of different crops in the discounting model. The crops with higher discounting are concentrated in cucumber, which has a very significant unsalable amount in 2027 and 2029. Water spinach and barley also have a large unsalable amount in several years.

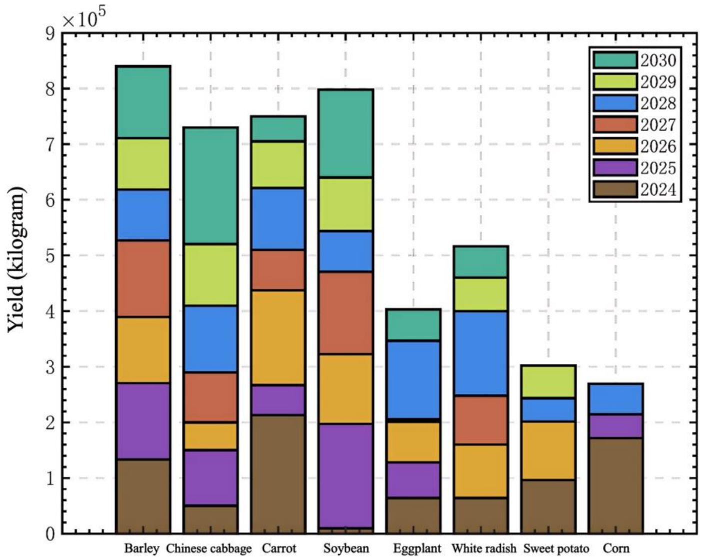

**Figure 2.** Discount vegetable data for the next 7 years

### 4.3. Solution of uncertain factor planting model based on stochastic programming

According to the solution steps of the first question, the following solution results are obtained. The following table shows the model solution results of some food crops under uncertain factors, and the following table only shows the planting situation of some food crops in 2024.

**Table 3.** Model solution results under uncertain factors (part)

| Plot name | Soya beans | Plot name | barley | Plot name | Broomcorn millet |
|---|---|---|---|---|---|
| A1 | 80 | A4 | 72 | A6 | 55 |
| A2 | 55 | B4 | 28 | C2 | 13 |
| A3 | 35 | B5 | 25 | | |
| B2 | 46 | B6 | 86 | | |
| B3 | 40 | B8 | 44 | | |
| B7 | 55 | B10 | 25 | | |
| B14 | 20 | C1 | 15 | | |
| C5 | 27 | C6 | 20 | | |

Table.3 shows the part of the calculations for the 2024 food planting plan, which meet the criteria for large-scale planting. Using this large-scale centralized planting method can facilitate unified management, improve production efficiency, and match the planting scale in 2023. The figure below shows the total profit per year derived from this stochastic programming.

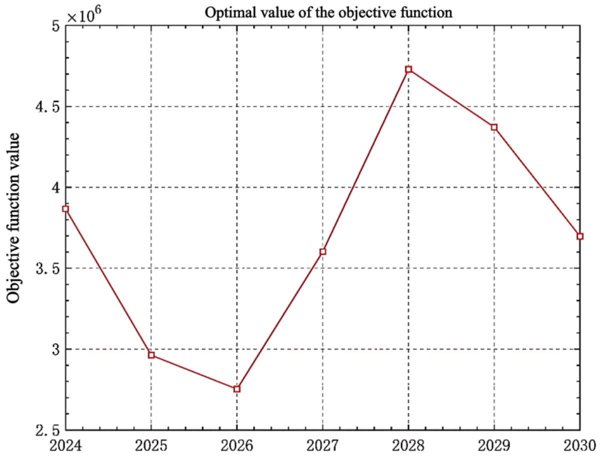

**Figure 3.** Total profit per year for the next 7 years

Figure.3 shows the forecast data from 2024 to 2030, and the profits in the chart decline to a certain extent each year, rising year by year from 2026, reaching a peak of about 4.7 million in 2028, and then declining year by year, falling to 3.7 million in 2030. The conclusion drawn in this question shows some similarity in trend with the annual profit data obtained in the previous study. However, there are also fundamental differences. These differences reflect the significant impact of natural conditions and market factors on the profitability of farming.

## 5. Conclusion

In this paper, the optimal planting scheme of crops in the next 7 years is studied under the two conditions of unsalable waste and discount sale by using the single objective programming model and stochastic programming model. The following conclusions are drawn: First, based on the maximum of total profit in the next 7 years as the objective function, the optimal planting plan under the condition of unsalable waste and discount sale is obtained, and the total profit in the next 7 years is 11.37 million yuan and 23.77 million yuan. Under the stochastic programming model with the maximum uncertain profit, the total profit of the next seven years is 25.26 million yuan. Through the sensitivity analysis of the range fluctuation of random factors by 5%, the total profit fluctuation of the next seven years is controlled within 3%.

In view of the above conclusions, this paper puts forward the following policy suggestions: First, develop agriculture according to local conditions. According to the natural conditions and market demand of the region, the forecast analysis should be carried out to meet the market demand for high-quality agricultural products; The second is the intelligent management and optimization strategy of agricultural planting driven by big data. Big data technology is used to provide new possibilities for intelligent management of agricultural planting. Intelligent management of agricultural planting is discussed from the aspects of farmland management, disease and pest forecasting and management, and crop growth monitoring, and optimization strategies are proposed in terms of resource optimization, crop quality optimization, and agricultural sustainability. Finally, it is to establish a perfect planting development plan, including optimizing the industrial structure, promoting green production mode, improving the quality, efficiency and competitiveness of planting industry.

## References

[1] Huang Guoqin, Zhao Qiguo. Rotation fallow patterns and development strategies in typical areas of China [J]. Acta Pedologica Sinica, 2018, 55 (02): 283-292.

[2] Lin Dayan, Zhu Jing. Reasons for changes in planting structure of major crops in China from the perspective of supply elasticity [J]. Journal of Agrotechnical Economics, 2015, (01): 33-41.

[3] DING Guocai, Duan Zaiyan, WANG Dingshi, on the significance of arable land rotation fallow to agricultural sustainable development [J]. Agricultural Development and Equipment, 2022, (05): 88-90.

[4] FENG Guangliang. Research on agricultural planting structure allocation in lower reaches of Tarim River based on two-layer planting optimization model [J]. Water Conservancy Technical Supervision, 2024, (05): 213-217.

[5] Wu M H. Analysis of crop water requirement and planting optimization in typical irrigation area of Yerqiang River, Xinjiang [D]. North China electric power university (Beijing), 2023.

[6] LI M M. Study on optimization of agricultural planting structure in irrigated areas under the constraint of irrigation water utilization efficiency [D]. The northeast agricultural university, 2022.

[7] Li Yanbin, Ma Jiatong, Li Daoxi, et al. Improved particle swarm algorithm in the application of agricultural planting structure optimization [J]. Journal of irrigation and drainage, 2022, 9 (01): 62-71.

[8] LI Yanbin, Ma Jiatong, Li Daoxi, Wang Fei. Application of improved particle swarm optimization in agricultural planting structure. Journal of Irrigation and Drainage. 2022, 41 (01): 62-71

[9] LIU L S. Establishment of mathematical model of recent planting structure of main crops in Shulu County by linear programming [J]. Agricultural Technical Economics, 1983, (08): 44-46+40.

[10] The value and strategy of agricultural technology extension in agricultural planting. Grain, Oil and Feed Science and Technology, 2024, (03): 104-106.