

CUMCM-2024 Problem C

Crops Cultivation Plan

Based on the actual conditions of the village, there is great practical significance to make full use of limited arable lands to develop organic farming industry. Selecting suitable crops and optimizing the cultivation plan for field management, is beneficial to product efficiency and reduce the various risks of planting.

A village is located in the mountainous area of North China, with a relatively low temperature throughout the year. Most arable lands in this village can only be planted once a year. The village has 1,201 mu of open field land, which can be divided into 34 plots of different sizes, including four types: flat dry lands, terraced fields, sloped lands, and irrigated lands. Flat dry lands, terraced fields, and sloped lands are suitable for single-season grain crops each year. Irrigated lands are suitable for single-season rice or two-season vegetables each year. Also, there are 16 ordinary greenhouses and 4 smart greenhouses, each of which is 0.6 mu. Ordinary greenhouses are suitable for single-season vegetables and single-season edible fungi each year. Smart greenhouses are suitable for two-season vegetables each year. One plot (including greenhouses) can be intercropped with different crops each season (See Annex 1).

According to the growth patterns, no crop can be continuously replanted in the same plot (including greenhouses), otherwise production will be reduced. Since soil containing leguminous rhizobia is beneficial for other crops, leguminous crops must be planted in every plot (including greenhouses) at least once within three years since 2023. At the same time, the cultivation plan should take into account the convenience of cultivation operations and field management. For example, the cultivation area for each crop should not be too dispersed in each season, and the cultivation area for each crop in a single plot (including greenhouses) should not be too small, etc. The crop planting and related statistical data for 2023 are shown in Annex 2.

Please establish a mathematical model to study the following problems:

Problem 1 Assuming that the expected sales, planting cost, yield per mu, and selling price of various crops remain stable compared to 2023. The crops planted each season are sold in the same season. If the total yield of a certain crop in a season exceeds the expected sales, the excess part cannot be sold normally. Please provide the optimal cultivation plans from 2024 to 2030 based on the following two situations, and fill the results into result1_1.xlsx and result1_2.xlsx respectively (the template files are in Annex 3).

(1) The excess part will be unsold, causing waste;

(2) The excess part will be sold at a 50% discount from the 2023 sales price.

Problem 2 Based on experience, the expected sales of wheat and corn in the future is showing an increasing trend, with an average annual increasing rate 5%~10%. The expected annual sales of other crops in the future will fluctuate around $\pm 5\%$ compared to 2023. The yield of crops per mu is often affected by climate, with an annual variation of $\pm 10\%$. Due to market conditions, the average annual cost of crop cultivation increases by about 5%. The selling price of grain crops is mostly stable, while the selling price of vegetable crops is showing an increasing trend, with an average annual increase of about 5%. The selling price of edible fungi is stable with a slight decrease, with an annual reduction of about 1%~5%, especially the selling price of morels decreases by 5% annually.

Taking into account the uncertainties and potential planting risks of the expected sales, yield per mu, planting costs, and selling prices of various crops, please provide an optimal crop cultivation plan for 2024–2030, and fill the results into result2.xlsx (the template file is in Annex 3).

Problem 3 In the reality, there may be certain substitutability and complementarity among various

crops, and the expected sales are also correlated with selling price and planting costs. Based on Problem 2, considering the related factors comprehensively, please provide an optimal crop cultivation plan for 2024~2030. Solve the model with simulated data, and compare the results with those of Problem 2.

Annex 1 Basic situations of the existing arable land and crops.

Annex 2 The crop planting and related statistical data for 2023.

Annex 3 Template files for the required results (result1_1.xlsx, result1_2.xlsx, result2.xlsx).