Vague Adaptive Optimization Based Research on Western Guangdong Province Favorable Natural Rubber Species

Jun Jiang1,2, Junfeng Wang2, Hongxu Wang1 and Huijian Zhang1,2,*

1School of Tourism, Hainan Tropical Ocean University (HNTOU), Sanya 572022, Hainan, P. R. of China
2Institute of Scientific and Technical Information, Chinese Academy of Tropical Agricultural Sciences (CATAS), Haikou 571101, Hainan, P. R. of China

*Corresponding author e-mail: zanghuijian@catas.cn

Abstract. Apply vague adaptive optimization method to find new natural rubber species. It is advisable to accelerate the promotion of wind-resistant and high-yield natural rubber species’ plantation in the dominant areas of western Guangdong Province, which are Reyan 7-33-97, Yunyan 77-2, Dafeng -95, Yunyan 77-4, Haiken 1, PR 107, RRIM 600, RRII 208 and other species.

Keywords: Vague Applicability Optimization Method, Western Guangdong, Natural Rubber Species

1. Introduction

From a long-term perspective, due to the restriction of climate conditions on the production of natural rubber, the suitable land resources for natural rubber planting are limited (according to statistics of rubber planting countries in the world, there are still about 66667 km² of land where is suitable for rubber planting in the world), and the protection of environmental diversity of tropical rain forests in many countries is strengthened, the contradiction between supply and demand of natural rubber may become more and more outstanding in the future. In order to alleviate the contradiction between supply and demand of natural rubber, in addition to continuing to develop new rubber plantations and updating old rubber plantations, applying new technology to improve the species, increase the yield, develop new technology and improve the level of industry will become the trend of the natural rubber industry development in the future.

From the perspective of national security, rubber tree is a perennial economic crop. However, there is a long non-production period before the tree can really produce natural rubber. If China can not produce sufficient natural rubber and still relies on import excessively, it will be controlled by others once the world situation changes. Therefore, as an independent developing country, China, as the world's largest net importer of natural rubber, must plant natural rubber and guarantee produce as much natural rubber as possible to strive to narrow the gap between production and consumption in order to control China's natural rubber imports in the reasonable limit. The development goal of China's natural rubber plantation industry is to maximize the output of natural rubber and minimize the import of natural rubber.
At present, most of the major natural rubber producing countries in Asia are expanding their rubber planting areas except for Malaysia. These countries located in the tropical areas and rely on the expansion of natural rubber planting areas to increase the output of natural rubber. Natural rubber is mostly produced in areas with high temperature, high humidity and little wind damage, which is a large extent restriction for China's limited tropical land resources.

Meanwhile, China has 973,300 hm² of suitable rubber fields, 70% of which have been used as rubber planting areas, with an area of 666,700 hm². The remaining 30% are also occupied by other tropical crops. Moreover, most of China's natural rubber is planted in the 18-24 degrees of north latitude, which is generally considered incapable of producing rubber in the world. It belongs to the northern edge of the tropics, meanwhile natural disasters such as wind, cold, disease and drought are frequent [1].

Although the comparative advantages of natural rubber in Guangdong's dominant areas are limited, and even lack of comparative advantages in some aspects, it is not suitable to expand the planting area of natural rubber in China, but this cannot shake Guangdong's position as an dominant area for natural rubber production [2].

The water and heat conditions in Guangdong's dominant areas are good. With an average annual temperature of 22.2-23.3°C, 9-10 months with an average monthly temperature higher than 18°C, 14.3-16.3°C with an average monthly temperature of the coldest, and an annual rainfall of 1,600-2,200 mm, meet the demands of normal growth and rubber production of rubber trees. These areas include Xuwen, Leizhou, Suixi, Lianjiang, Dianbai, Huazhou, Gaozhou, Xinyi, Yangxi, Yangdong and Yangchun in western Guangdong Province, as well as parts of Jieyang and Shanwei in eastern Guangdong [3].

### 2. Natural Rubber Species to Be Optimized

Eight natural rubber species to be filtered, RRII 208, RRIM 600, PR 107, Reyan 7-33-97, Haiken 1, Dafeng -95, Yunyan 77-2 and Yunyan 77-4, are set by Vague adaptive optimization method in order to find natural rubber species which is suitable for planting in western Guangdong Province. The relevant parameters are shown in Table 1 [4-11].

| India RRII 208 | 5 Year Average Yield (kilogram/hectare/year) | 10 Year Average Yield (gram/tree/tap) | Mildew Resistance | Cold Resistance | Drought Resistance | Wind Resistance | TPD Resistance |
|----------------|---------------------------------------------|--------------------------------------|-------------------|-----------------|-------------------|----------------|----------------|
| RRIM 600       | 1,119                                       | 64.96                                | Medium            | High            | High              | Medium         | Medium-Low     |
| PR107          | 1,143                                       | 51.88                                | Medium            | Medium          | Medium            | Medium-High    | Medium         |
| Reyan 7-33-97  | 1,750                                       | 59.66                                | High              | Medium-High     | Medium-High       | High           | Medium-High    |
| Haiken 1       | 1,140                                       | 36.97                                | Medium-High       | Medium-High     | High              | High           | Medium-Low     |
| Dafeng -95     | 1,450                                       | 58.31                                | Medium-High       | High            | Medium-High       | High           | Medium-High    |
| Yunyan77-2     | 1,828                                       | 54.30                                | Medium-High       | High            | Medium            | High           | Medium-High    |
| Yunyan77-4     | 1,389                                       | 54.67                                | Medium-High       | High            | Medium            | High           | Medium-High    |

(Source: Internet)
3. Index Sets of Items to Be Optimized

Set index sets of items to be optimized as \( U = \{u_1, u_2, \ldots, u_n\} \), among which \( u_1 \) refers to “5 Year Average Yield (kilogram/hectare/year)”; \( u_2 \) refers to “10 Year Average Yield (gram/tree/tap)”; \( u_3 \) refers to “Mildew Resistance”; \( u_4 \) refers to “Cold Resistance”; \( u_5 \) refers to “Drought Tolerance”; \( u_6 \) refers to “Wind Resistance”; \( u_7 \) refers to “TPD Resistance”.

The higher value the index of each item has, the more preferred it will be. Index sets of items to be optimized are shown in Table 2.

| Index | \( u_1 \) | \( u_2 \) | \( u_3 \) | \( u_4 \) | \( u_5 \) | \( u_6 \) | \( u_7 \) |
|-------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Description | 5Year Average Yield (kilogram/hectare/year) | 10Year Average Yield (gram/tree/tap) | mildew resistance | cold resistance | drought tolerance | wind resistance | TPD resistance |
| Ideal Index | Big | Big | High | High | High | High | High |

4. Establishment of Species Sets to Be Optimized

Species sets to be optimized are defined as \( \{L_1, L_2, \ldots, L_n\} \), \( L_1 \) refers to India RRII 208; \( L_2 \) refers to Malaysia RRIM600; \( L_3 \) refers to Indonesia PR107; \( L_4 \) refers to Reyan7-33-97; \( L_5 \) refers to Haiken1; \( L_6 \) refers to Dafeng-95; \( L_7 \) refers to Yunyan77-2; \( L_8 \) refers to Yunyan77-4.

Species sets to be optimized are shown in Table 3.

| S/N | \( L_1 \) | \( L_2 \) | \( L_3 \) | \( L_4 \) | \( L_5 \) |
|-----|---------|---------|---------|---------|---------|
| Specie | RRII 208 | RRIM 600 | PR 107 | Reyan 7-33-97 | Haiken 1 |
| S/N | \( L_6 \) | \( L_7 \) | \( L_8 \) |
| Specie | Dafeng -95 | Yunyan 77-2 | Yunyan 77-4 |

All sets of species to be optimized are established on index sets \( U = \{u_1, u_2, \ldots, u_n\} \).

5. Extraction of Theoretically Ideal Species Sets

The theoretically ideal sets \( K \) are extracted from the data assembly of the species sets with the indicator for each item showing the highest degree of preference. Also refer to Table 4 for more details.

6. Conversions of Raw Data into Vague Data

In this research, there are two kinds of data, one is single value data, while the other is description data. And they will be changed into Vague data individually.

Table 4. The parameters of natural rubber species to be optimized (raw data)

| \( u_1 \) | \( u_2 \) | \( u_3 \) | \( u_4 \) | \( u_5 \) | \( u_6 \) | \( u_7 \) |
|---------|---------|---------|---------|---------|---------|---------|
| \( L_1 \) | 1,119.00 | 64.96   | Medium  | High    | High    | Medium  | Medium-Low |
| \( L_2 \) | 1,186.00 | 51.88   | Medium  | Medium  | Medium  | Medium-High | Medium |
| \( L_3 \) | 1,143.00 | 37.17   | High    | Medium  | Medium  | Medium-High | High |
6.1 Conversion of Single Value Data into Vague Data

Index \( u_1 \) and \( u_2 \) are single-valued data, and also larger value indicates higher preference degree, they can be applied in Vague data benefit conversion formula, so the benefit-type transformation formula of Value data is applied.

As is shown below.

If \( u_{j_{\text{max}}} = \max \{u_{i_1}, u_{i_2}, \cdots, u_{i_{\text{m}}}\} \) is defined, then \( L_i(u_j) = u_{ij} = [t_j, 1-f_j] = \left[ \left( \frac{u_j}{u_{j_{\text{max}}}} \right)^{u_i}, \frac{u_i}{u_{j_{\text{max}}}} \right] \) is the benefit-type transformation formula of Vague data converted from non-negative single-valued data \( u_i \), and then the Vague data are converted. As is shown in Table 5.

6.2 Conversion of Description Data into Vague Data

Index \( u_3, u_4, u_5, u_6 \) and \( u_7 \) are description data, to convert raw data into Vague data, the description data can be evaluated as High [0.86, 1.00]; Medium-High [0.70, 0.85]; Medium [0.54, 0.69]; Medium-Low [0.38, 0.53]; Low [0.22, 0.37], also as shown in Table 5.

Table 5 shows that the species sets to be optimized and also theoretically ideal species sets.

Table 5. The parameters of natural rubber species to be optimized (converted data)

| \( u_1 \) | \( u_2 \) | \( u_3 \) | \( u_4 \) | \( u_5 \) | \( u_6 \) | \( u_7 \) |
|----------|----------|----------|----------|----------|----------|----------|
| \( L_1 \) | 0.23,0.61 | [1.00,1.00] | [0.54,0.69] | [0.86,1.00] | [0.86,1.00] | [0.54,0.69] | [0.38,0.53] |
| \( L_2 \) | 0.27,0.65 | 0.49,0.79 | [0.54,0.69] | [0.54,0.69] | [0.54,0.69] | [0.70,0.85] | [0.54,0.69] |
| \( L_3 \) | 0.25,0.63 | 0.19,0.57 | 0.86,1.00 | [0.54,0.69] | [0.54,0.69] | [0.70,0.85] | 0.86,1.00 |
| \( L_4 \) | 0.88,0.96 | 0.75,0.91 | 0.86,1.00 | 0.70,0.85 | 0.54,0.69 | 0.86,1.00 | 0.70,0.85 |
| \( L_5 \) | 0.24,0.62 | 0.19,0.57 | 0.70,0.85 | 0.70,0.85 | 0.86,1.00 | 0.86,1.00 | 0.38,0.53 |
| \( L_6 \) | 0.49,0.79 | 0.70,0.89 | 0.70,0.85 | 0.86,1.00 | 0.70,0.85 | 0.86,1.00 | 0.70,0.85 |
| \( L_7 \) | 1.00,1.00 | 0.57,0.83 | 0.70,0.85 | 0.86,1.00 | 0.54,0.69 | 0.86,1.00 | 0.70,0.85 |
| \( L_8 \) | 0.44,0.76 | 0.59,0.84 | 0.70,0.85 | 0.86,1.00 | 0.54,0.69 | 0.86,1.00 | 0.70,0.85 |
| \( K \) | 1.00,1.00 | 1.00,1.00 | 0.86,1.00 | 0.86,1.00 | 0.86,1.00 | 0.86,1.00 | 0.86,1.00 |

7. Vague Sets Based Natural Rubber Species Optimization in Western Guangdong Province Dominant Area
Western Guangdong Province are focusing on promotion of the wind-resistant and high-yield species. Therefore, wind resistance is the most important resistance for natural rubber species in the dominant areas of western Guangdong Province. Then, try to find the species with high yield.

Therefore, the weight distribution of different item indexes of natural rubber species in the natural rubber production advantage area in western Guangdong Province are as follows:

\[u_1 = 0.1, \quad u_2 = 0.1, \quad u_3 = 0.1, \quad u_4 = 0.1, \quad u_5 = 0.1, \quad u_6 = 0.4, \quad u_7 = 0.1\]

On the assumption that the element \(u_i(i = 1, 2, \cdots, n)\) weights \(w_i \in [0, 1]\), and \(\sum_{i=1}^{n} w_i = 1\), then the formula \(\sum_{m=1}^{2} \alpha_{i m} - \alpha_{i 0 m} = 0\) is the weighted similarity measure between Vague sets \(L\) and \(K\).

Assume \(m = 2\), and apply the above-mentioned weighted similarity measure formula between Vague sets \(L\) and \(K\) to compute the weighted similarity measure between the Vague sets of species to be optimized and also theoretically ideal species according to the above-mentioned weight distribution.

The computing results are shown as follows.

\[M_2(L_1, K) = 0.588, \quad M_2(L_2, K) = 0.600, \quad M_2(L_3, K) = 0.617, \]
\[M_2(L_4, K) = 0.857, \quad M_2(L_5, K) = 0.712, \quad M_2(L_6, K) = 0.836, \]
\[M_2(L_7, K) = 0.847, \quad M_2(L_8, K) = 0.797. \]

According to the figures order of the weighted similarity measure, the preferred order of the wind-resistant natural rubber species are as follows.

\[L_4 f L_7 f L_6 f L_8 f L_5 f L_3 f L_2 f L_1. \]

(Symbol “f” represents “better than”)

The order of selection and decision-making for species in Western Guangdong Province natural rubber production advantage areas is as follows: \(L_4\) (Reyan 7-33-97), \(L_7\) (Yunyan 77-2), \(L_6\) (Dafeng-95), \(L_8\) (Yunyan 77-4), \(L_5\) (Haiken 1), \(L_3\) (PR 107), \(L_2\) (RRIM 600) and \(L_1\) (RRII 208).

8. Conclusions

Through Vague adaptive optimization, the following conclusions can be obtained. In the western Guangdong Province, the promotion of wind resistance species with fast-growing and high yield is given priority to plant. Suitable natural rubber species are Reyan 7-33-97, Yunyan 77-2, Dafeng -95, Yunyan 77-4, Haiken 1, PR 107, RRIM 600 and RRII 208.

Acknowledgements

This is a periodical result of the Hainan Natural Science Foundation (717156) and Sanya Supporting Fund Project (2017PT32).

References

[1] Office for the Development of Southern Tropical Crops under Ministry of Agriculture. National Natural Rubber Advantage Regional Layout Plan (2008-2015) . Beijing: Office for the Development of Southern Tropical Crops under Ministry of Agriculture, 2008

[2] China Natural Rubber Advantage Regional Layout Plan . Agricultural Engineering and Technology (Agri-product Processing), 2009(10):4-7

[3] NY/T 607—2002, Technical Specification for Rubber Tree Breeding

[4] SONDANG ANGGRAINI. RUBBER INDUSTRY IN INDONESIA:Present Status, Opportunities, Challenges and Strategies[R]. Ho Chi Minh City:ANRPC, 2009
[5] RUBBER INDUSTRY IN MALAYSIA: STATUS, OPPORTUNITIES, CHALLENGES AND STRATEGIES [R]. Ho Chi Minh City: ANRPC, 2009

[6] Tran Thi Thuy Hoa. RUBBER INDUSTRY IN VIETNAM: PRESENT STATUS, OPPORTUNITIES, CHALLENGES and STRATEGIES [R]. Ho Chi Minh City: ANRPC, 2009

[7] Ida Yunia Soependi. Indonesian Natural Rubber: An Econometric Analysis of its Export Supply and Foreign Import Demand [D]. East Lansing: Michigan State University, 1993

[8] Chan Weng Hoong. Growth and Early Yield of RRIM 2000 Series Clones in Trial and Commercial Plantings [R]. Siem Reap, Cambodia. IRRDB, 2007

[9] HAN WENG HOONG, ONG TEE SAN. Enhancing the Sustainability of Rubber Plantations in Peninsular Malaysia [R]. Selangor: APPLIED AGRICULTURAL RESEARCH, 2000

[10] James Jacob, Toms Joseph. Climate Change and Natural Rubber [R]. Bangkok: ANRPC, 2008

[11] Hidde P Smit. Outlook for the global rubber industry [R]. Bangkok: ANRPC, 2008