Vague Adaptive Optimization Based Research on Yunnan Favorable Natural Rubber Species

Jun Jiang¹, Junfeng Wang², Hongxu Wang¹ and Huijian Zhang²¹*¹

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

*Corresponding author. Email: danielchyang@126.com

Abstract. Based on Vague adaptive optimization method, taking traditional natural rubber species Indonesia PR107 and Malaysia RRIM600 as reference objects to optimize new natural rubber species. The conclusion of this study shows that it is advisable to promote and plant the cold-resistant and high-yield natural rubber species, including Yunyan 77-2, Yunyan 77-4 and Indian RRII 208.

Keywords: vague adaptive optimization method, Yunnan, natural rubber species.

1. Introduction
As a country with the fastest growth rate of natural rubber (hereafter referred as NR) consumption in the world, China's self-sufficiency production rate has been decreasing year by year. According to official data of government, China’s dependence of NR on foreign countries has exceeded 80%. At present, China is the world's largest net importer of NR. It is important to produce NR as much as possible. Meanwhile, striving to narrow the gap between production and consumption in order to control China's NR imports in a reasonable limit.

Under the constraints of limited natural resources and relatively poor natural conditions, the development of China's NR industry depend on enlarging the harvesting areas and improving the yield. With the research of cold-resistant NR species, it is of vital strategic significance to "move north" the NR planting area, increase the planting area and increase the NR output.

2. NR species to be optimized
Using Vague adaptive optimization method, taking traditional NR species Indonesia PR107 and Malaysia RRIM600 as referencial objects, Yunyan 77-2, Yunyan 77-4 and India RRII 208 were selected as simple to find NR species which are suited for planting in Yunnan.
Table 1. The parameters of selected NR species.

| Parameters                  | Species         | 5 Year Average Yield (kilogram/hectare/year) | 10 Year Average Yield (gram/tree/tap) | Mildew Resistance | Cold Resistance | Drought Tolerance | Wind Resistance | TPD Resistance |
|-----------------------------|-----------------|---------------------------------------------|--------------------------------------|-------------------|-----------------|------------------|----------------|----------------|
|                            | India RRII 208  | 1.119                                       | 64.96                                | Medium            | High            | High             | Medium         | Medium-Low     |
|                            | RRIM 600        | 1.186                                       | 51.88                                | Medium            | Medium          | Medium           | Medium-High    | Medium         |
|                            | PR 107          | 1.143                                       | 37.17                                | High              | Medium          | Medium           | Medium-High    | High           |
|                            | Yunyan 77-2     | 1.828                                       | 54.30                                | Medium-High       | High            | Medium           | High           | Medium-High    |
|                            | Yunyan 77-4     | 1.389                                       | 54.67                                | Medium-High       | High            | Medium           | High           | Medium-High    |

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.

Table 2. Index sets of items to be optimized.

| Index | \( u_1 \) | \( u_2 \) | \( u_3 \) | \( u_4 \) | \( u_5 \) | \( u_6 \) | \( u_7 \) |
|-------|----------|----------|----------|----------|----------|----------|----------|
| Description | 5 Year Average Yield (kilogram/hectare/year) | 10 Year 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 \( \{L_1, L_2, L_3, L_4, L_5\} \), \( L_1 \) refers to India RRII 208; \( L_2 \) refers to Malaysia RRIM 600; \( L_3 \) refers to Indonesia PR 107; \( L_4 \) refers to Yunyan 77-2 and \( L_5 \) refers to Yunyan 77-4.

Species sets to be optimized are shown in Table 3.

Table 3. Species sets to be optimized.

| S/N | \( L_1 \) | \( L_2 \) | \( L_3 \) | \( L_4 \) | \( L_5 \) |
|-----|----------|----------|----------|----------|----------|
| Specie | RRII 208 | RRIM 600 | PR 107   | Yunyan 77-2 | Yunyan 77-4 |

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

Refer to Table 5 for more details.
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.

Refer to Table 4 for more details.

| $u_1$ | $u_2$ | $u_3$ | $u_4$ | $u_5$ | $u_6$ | $u_7$ |
|-------|-------|-------|-------|-------|-------|-------|
| 1.828.00 | 64.96 | High | High | High | High | High |

6. **Conversion 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.

| $u_1$ | $u_2$ | $u_3$ | $u_4$ | $u_5$ | $u_6$ | $u_7$ |
|-------|-------|-------|-------|-------|-------|-------|
| $L_1$ | 1,119.00 | 64.96 | Medium | High | High | Medium-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 |
| $L_4$ | 1,828.00 | 54.30 | Medium-High | High | Medium | High | Medium-High |
| $L_5$ | 1,389.00 | 54.67 | Medium-High | High | Medium | High | Medium-High |
| $K$ | 1,828.00 | 64.96 | High | High | 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 $u_{j_{\text{max}}} = \max\{u_{j_1}, u_{j_2}, \ldots, u_{j_m}\}$ is defined, then $L_j(u_j) = u_j^* = [t_{j_0}, 1 - f_{j}] = \left(\frac{u_{j_0}}{u_{j_{\text{max}}}}, \frac{u_{j}}{u_{j_{\text{max}}}}\right)$ is the benefit-type transformation formula of Vague data converted from non-negative single-valued data $u_j$, and then the Vague data are converted. As is shown in Table 6.

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 6.

Table 6 shows that the species sets to be optimized and also theoretically ideal species sets.
Table 6. The parameters of NR species to be optimized (converted data).

| L   | u₁ | u₂ | u₃ | u₄ | u₅ | u₆ | u₇ |
|-----|----|----|----|----|----|----|----|
| L₁  | [0.23,0.61] | [1.00,1.00] | [0.54,0.69] | [0.86,1.00] | [0.54,0.69] | [0.54,0.69] | [0.38,0.53] |
| L₂  | [0.27,0.65] | [0.49,0.79] | [0.54,0.69] | [0.54,0.69] | [0.70,0.85] | [0.54,0.69] |
| L₃  | [0.25,0.63] | [0.19,0.57] | [0.86,1.00] | [0.54,0.69] | [0.86,1.00] |
| L₄  | [1.00,1.00] | [0.57,0.83] | [0.70,0.85] | [0.86,1.00] | [0.70,0.85] |
| L₅  | [0.44,0.76] | [0.59,0.84] | [0.70,0.85] | [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] |

7. Basic facts about NR production areas in Yunnan dominant area
The comparative advantages of Yunnan’s dominant areas is obvious. These advantages is also conducive to consolidating the existing industrial foundation. Appropriately expanding the planting scale, transforming low-yield and low-quality rubber plantations, and continuously improving the output per unit area.

The dominant area in Yunnan has the feature of both continental climate and marine climate. The average temperature is between 20-23℃ annually, the average monthly temperature is above 18℃ in 8-9 months, the average monthly of coldest temperature is between 14.4-16℃, and the annual precipitation is between 1,200-1,700 mm. The annual precipitation from May to October accounts for about 90% of the total annual precipitation. High temperature and high humidity in the same season are beneficial to the growth and rubber production. The annual rainfall from November to February next year is 3-8% of the total amount of the year. Drought and low temperature are also in the same period, which is favorable for rubber trees to overwinter. There is no typhoon in dominant area, the soil layer is deep and fertile, the climate is warm and humid, the daily temperature difference is as high as 18℃, which is conducive to the accumulation of photosynthesis products and rubber production. Meanwhile, the yield of Yunnan’s dominant area is at advanced level around the world. These dominant area includes Xishuangbanna, Puer, Honghe, Lincang, Dehong, Wenshan 6 places (autonomous states) and 29 counties (cities).

8. NR species optimization in Yunnan dominant area based on Vague sets
Cold resistance is the most important feature for NR species in Yunnan’s dominant regions, then choose the species with the high yield feature.

Therefore, the weight of different indexes of NR species in Yunnan dominant area is put as follows.

\[ u₁ = 0.1, \ u₂ = 0.1, \ u₃ = 0.1, \ u₄ = 0.1, \ u₅ = 0.4, \ u₆ = 0.1, \ u₇ = 0.1 \]

On the assumption that the element \( uᵢ (i=1,2,\cdots,n) \) weights \( wᵢ \in [0,1] \), and \( \sum_{i=1}^{n} wᵢ = 1, \ m = 0,1,2,\cdots \), then the formula \( WT_m (L, K) = \sum_{i=1}^{n} wᵢ \cdot \frac{3}{3+4\left(fᵢ^{(m)} - fᵢ^{(m)} \right)} \) 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 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.

\[ M_2 (L₁, K) = 0.747, \ M_2 (L₂, K) = 0.481, \ M_2 (L₃, K) = 0.551, \]

\[ M_2 (L₄, K) = 0.847, \ M_2 (L₅, K) = 0.797 \]
According to the order of the weighted similarity measure figure from large to small, the preferred order of the cold-resistant NR species are as follows.

$$L_3 \succ L_5 \succ L_4 \succ L_9 \succ L_2$$

(Symbol “$\succ$” represents “better than”)

The order of selection and decision-making for species in Yunnan NR production dominant areas is as follows: $L_4$ (Yunyan 77-2), $L_5$ (Yunyan 77-4), $L_1$ (India RRII 208), $L_3$ (Indonesia PR 107) and $L_2$ (Malaysia RRIM 600).

9. Conclusion
Through Vague adaptability optimization, it is appropriate to promote cold-resistant and high-yield rubber tree species in Yunnan’s dominant regions, and to plant species such as $L_4$ (Yunyan 77-2), $L_5$ (Yunyan 77-4) and $L_2$ (India RRII 208).

The above conclusions are consistent with the experience of experts, which shows that Vague adaptive optimization method is suitable for studying the selection of NR species for different purpose. The result is ideal. Meanwhile, it also provides a new method for solving such problems.

Therefore, the promotion of improved species should be placed in the top priority of technical innovation. Domestic high quality species should be widely selected when developing new rubber plantations and renewing old rubber plantations. Cultivate the second generation of high and stable yield rubber plantation with reasonable planning and layout, optimized species allocation, rationalize forest land renewal and standardized management will help to alleviate the contradiction between supply and demand of NR in China.

Acknowledgement
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) [R]. Beijing: Office for the Development of Southern Tropical Crops under Ministry of Agriculture, 2008.
[2] China Natural Rubber Advantage Regional Layout Plan [J]. Agricultural Engineering and Technology (Agri-product Processing), 2009(10):4-7.
[3] NY/T 607—2002, Technical Specification for Rubber Tree Breeding[S].