EVALUATING THE RESOURCES OF *RAPHANUS SATIVUS* L. FOR DUAL PURPOSE OF SIGHTSEEING AND GREEN MANURE BASED ON GREY CORRELATION ANALYSIS UNDER THE RURAL REVITALIZATION STRATEGY IN GUIZHOU

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Abstract. We evaluated the field performance of six new *Raphanus sativus* L. varieties (Brassicaceae family) for landscape and ecological values with the aim to find new ways of improving the cultivated land quality and develop Chinese countryside. Eleven indices were observed, including total flower number, total flower area, flowering stage, initial flowering stage, and nutrient content of returning field. The weighted correlation degree was calculated using coefficient of variation, and the evaluation was carried out using the grey correlation analysis. There were differences between the ranking of equal weight correlation degree and ranking of weighted correlation degree. The weight in total flower area, flower number, and average flower height was high according to the indices of landscape value; weight of fresh grass yield was medium according to the indices of growth; and the weight of phosphorus and potassium was high according to the indices of ecological value of green manure. Three varieties were ranked in the top three according to equal weight correlation degree and weighted correlation degree. They also yielded the best results based on the grey correlation analysis of coefficient of variation. Thus, these three resources could be given priority for use in green manure technology.
Keywords: *ecological value, flowering period, area of flower, returnable nutrient characteristics*

Introduction

Green manure (GM) is a crop that can be directly or indirectly returned to the field during its growth, and the value of GM is partially equivalent to that of chemical fertilizers and the soil. It can also be planted together with the main crops to promote their growth and improve soil properties (Cao et al., 2010). GM is an important crop that contributes to soil fertility, and it is a good solution to problems ensued from cultivating land and sourcing organic fertilizers (Cao et al., 2017). GM in China is rich in germplasm resources, which can be divided into 10 families, 42 genera, and more than 60 species, with a total of more than 1,000 varieties. Among them, 4 families, 20 genera and 26 species are widely used, and there are approximately 500 varieties (Cao et al., 2007). To improve rural landscape and develop GM technology, the ornamental

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nature of GM crops has an important developmental value (Zhang et al., 2018; Zhang et al., 2020). Regional seasonal idle cultivated lands such as winter idle paddy field in the south and winter idle dry land in the southwest are suitable for the growth of GM (Cao et al., 2017), which includes *Brassica campestris* L., *Raphanus sativus* L. (RL), and *Orychophragmus violaceus* L. as the cruciferous GM. In Wuyuan, rotating *B. campestris* in winter fallow rice fields promotes tourism because it creates a visually appealing farmland landscape during its flowering period (Zhang et al., 2018). In particular, the "rape flower sea" in the Yangtze River Basin strongly enhanced local tourism and related industries (Yang et al., 2018), with *O. violaceus* blooms also providing a high sightseeing value (Ji, 2018). Therefore, the innovative utilization of GM germplasm resources, its value-addition, and the increase in technological efficiency have always been the focus of research in this area (Cao et al., 2017). With a view to ensure the conservation of cultivated land and meet the developmental needs of the beautiful countryside, it is important to explore, screen, and evaluate the sightseeing GM germplasm resources. RL belongs to the Cruciferae family, and it has a long sowing date and good growth suitability; thus, it is being used as a traditional cruciferous GM crop in southern China. Although the GM of RL does not have nitrogen-fixation function, as leguminous GM, it is easy to use P, K, and other insoluble nutrients in the soil (Zhao et al., 1999). Additionally, its terminal inflorescence has white cross-shaped flowers, early flowering time, and long flowering period, as well as good ornamental value. In this experiment, RL was used as the research object, and six newly introduced resources were selected. The landscape indices such as visual, temporal, and spatial characteristics, GM growth index, and ecological value were selected for observation and comparison. The grey correlation analysis was used for comprehensive evaluation. This study aimed to explore the germplasm resources for the sightseeing rotational cultivation of GM, enhancing the soil quality and improving the rural landscape.

Materials and Methods

Site Description and Experiment Design

The experiment was carried out in a farmland (E105.83596, N26.90817) in Zhijing County, Bijie City, Guizhou Province in 2019. The site is located in the west-central part of Guizhou Province at an altitude of 1217 m. This location specific has a humid subtropical monsoon climate with obvious monsoon alternation. The temperatures throughout the year are mild with an annual average of 14.7℃. The previously cultivated crop was corn, with an average yield of 6300 kg/hm^2 across 3 years (2017-2019). The tested field has yellow soil with pH 5.62, total nitrogen 2.18 g/kg, total phosphorus 0.71 g/kg, total potassium 9.8 g/kg, alkali-hydrolyzable nitrogen 139 mg/kg, available phosphorus 16.8 mg/kg, rapidly available potassium 87 mg/kg, and organic matter 28.13 g/kg.

The RL samples were provided by the National Green Manure Industry System of China. A total of six treatments were set. R1 was Ganfeiluo 1 from Jiangxi Red Soil Institute, R2 was Qujing local variety from Yunnan Province, R3 was Oil Radish 1 from Wuhan Institute of Agricultural Science, R4 was Duanye 13 from Ganzhou, Jiangxi Province, R5 was Ganzhou local variety from a market in Ganzhou, Jiangxi Province, and R6 was Kunming local variety from Yunnan Province. The germplasms did show the same phenotype in our study, indirectly indicating a difference among the six

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varieties. The plot area was 15 m^2 (5 m × 3 m), and there were 18 plots in total. The seeds of all crops were sown at the sowing density of 9 kg/hm^2 om October 21, and crops were grown without any fertilizer.

Sample Collection and Statistical Analysis

In the flowering stage, three representative plants from each plot were collected. After transferring the samples to the lab, the aboveground and underground fresh matter was washed with deionized water, dried, and weighed to determine the total content of nitrogen, phosphorus, and potassium. Plant total nitrogen content was determined using the FOSS Kjeltec™ 8200 Auto Sampler System (Eden Prairie, USA). TP content was determined using the molybdate-ascorbic acid method with the H_2SO_4–H_2O_2 digestion method. TK content was determined using ICP-OES (Perkin Elmer, USA). Diverse parameters were calculated using the following formulae.

Single flower area of RL:

$$S_R = \pi\times(A_R/2)\times(B_R/2) \quad \text{(Eq.1)}$$

where, A_R is the length of the single floret flag and B_{LC} is the width of the single floret flag.

Unit area of flower area of RL:

$$S = S_R\times C\times D \quad \text{(Eq.2)}$$

where, C is the number of plants per unit area and D is the number of flowers in a plant.

Carbon fixation was calculated based on the photosynthetic equation: every 1.00 g of plant dry matter fixes 1.63 g of atmospheric CO_2 and releases 1.20 g of O_2. The afforestation cost in China is 260.9 CNY/t and the current price of industrial oxygen is 400 CNY/t (Zheng et al., 2021). The exchange rate between CNY and USD is 1:0.1493.

Six germplasm resources were regarded as a grey system (i) using the grey system theory. According to the screening objectives, the traits of the reference resources were determined. In the following formula, Xij (k) is the value after dimensionless, X'ij (k) is the value before dimensionless, X0 (k) is the value of the reference varieties, and k is the number of traits. Positive index: Xij (k) = X'ij (k)/X0 (k); reverse index: Xij (k) = X0 (k)/X'ij (k); neutral index: Xij (k) = X0 (k)/(X0 (k) + | X0 (k) - X'ij (k) |).

As the reference resource (X0), each trait index of X0 was taken as the reference sequence (X0k), k was the investigated trait, and each trait index of six resources was taken as the comparison sequence (Xik). The following formulae were used to calculate the correlation coefficient, equal weight correlation degree, and weighted correlation degree between six test resources and reference resources, and the ranking of the test resources was evaluated according to the weighted correlation degree (Zhang, 2009; Zan et al., 2018; Chen et al., 2020).

$$\xi = \frac{\min_i \min_k |X_{0k} - X_{ik}| + \rho \max_i \max_k |X_{0k} - X_{ik}|}{|X_{0k} - X_{ik}| + \rho \max_i \max_k |X_{0k} - X_{ik}|} \quad \text{(Eq.3)}$$

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} \xi_{ik} \quad \text{(Eq.4)}$$

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$$\Delta\gamma_i = \sum_{k=1}^{n} \omega_k \xi_{ik} \tag{Eq.5}$$

Excel 2007 and SPSS 18.0 were used for statistical analyses of the data. Analysis of variance (ANOVA) was carried out to determine the differences between the measured parameters for different treatments. The least significant difference (Duncan) at p = 0.05 was used to elucidate any significant differences. Excel 2007 was used for plotting. Data in the chart are presented as mean ± standard error.

Results

Landscape Characteristics of the Tested Resources

The RL flowers produce a comprehensive visual perception in time, space, and area, enabling a three-dimensional view. In terms of flowering period (*Fig. 1*), it mainly extends from early March to early April and lasts approximately 16–20 days. There is little difference in the flowering duration among the tested resources; R3 has the shortest, whereas R1 has the longest. However, flowering time differed significantly; the flowering periods of R2, R4, and R6 were early March; R1 and R3 flower in mid-March; and R5 flowers in late March. In general, R6 flowers the earliest and R5 the last. With regard to the spatial characteristics of the flowers, they are terminal inflorescences, and the plant height mainly ranges between 45 and 155 cm. GM differed in height, with R1 being the tallest; R2, R3, and R5 in between; whereas R4 and R6 being the shortest. The total flower area per unit (*Fig. 2*) was the variable that most affected visual perception. Affected by the number of flowers per unit and the area of a single flower, the total flower area per unit of RL is approximately 0.28–1.12 m^2/m^2, with an average of approximately 0.55 m^2/m^2. It is noteworthy that the total flower area per unit of R3 is significantly larger than that of others; the total flower area per unit of R2 is significantly larger than that of R4. Although R4 flowers had the smallest area, they are still reasonably large at 0.32 m^2/m^2. The tile area dominates one third of the unit area, and the visual effect is relatively good. Overall, RL has a long flowering period, a large number of flowers, suitable height distribution of flowers, a large tile area, and a terminal inflorescence free from the shade of the grass, and contributes to beautiful landscapes.

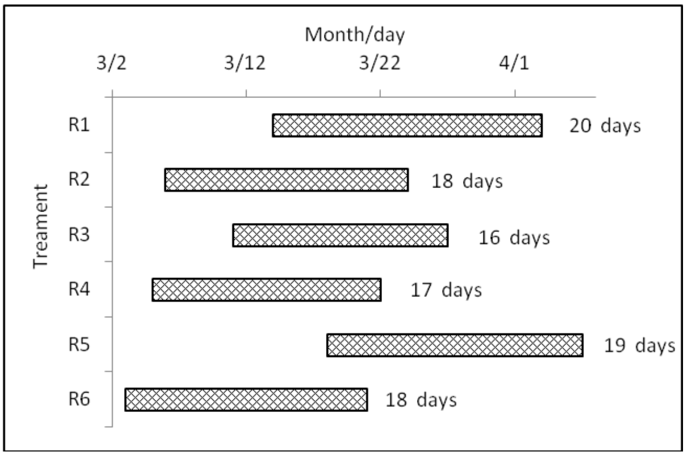

Figure 1. *Flowering period of green manure under different treatments*

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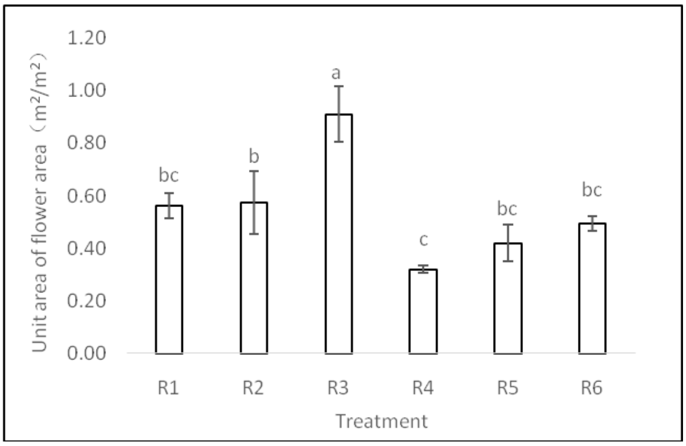

Figure 2. *Area of flowers of green manure under different treatments. Note: Different small letters indicate a significant difference at P≤0.05*

Returnable Nutrient Characteristics of the Tested Resources

GM crops can be returned to the field to provide nutrients for the soil. As a cruciferous GM, the nutrient content of RL is higher and the yield of fresh grass is higher than those of leguminous GM. Therefore, RL has great potential of nutrient interception and supply to the field (*Fig. 3*). In terms of aboveground nutrient content, the total N, P, and K content in RL is 2.358%–3.814%, 0.231%–0.378%, and 2.447%-4.325%, respectively. The yield of aboveground fresh grass is 31.52-68.64 t/hm^2, with an average of 52.78 t/hm^2. Returning fresh grass to the field can supply soil nutrients; the content of N, P, and K is 145.14–295.10, 14.62–37.73, and 148.56–372.15 t/hm^2, respectively. The N nutrient content in R2 and R5 is significantly higher than that in R6; the P nutrient content in R2 is significantly higher than in the others; the K nutrient content of R3 is significantly higher than that of R1, R2 and R6. The total aboveground nutrients can be returned to the field at 326.74–679.38 kg/hm^2, in the following order: R5 > R3 > R2 > R4 > R6 > R1. In terms of underground nutrient content, the total N, P, and K content in RL is 0.511%–1.975%, 0.115%–0.225%, and 2.725%–3.821%, respectively. The yield of the underground significantly different, ranging from 1.27 to 53.74 t/hm^2, with an average of 17.69 t/hm^2. Regarding the returnable nutrients of the underground, the N nutrient content in R5 is significantly higher than that in R2, R4, and R6; the P nutrient content in R5 is significantly higher than that in R1 and R6; and the K nutrient content in R5 is significantly higher than that in R1, R2, R4, and R6. The total nutrients in the underground can be returned to the field at approximately 20.33–295.62 t / hm^2, in the following order: R5 > R3 > R4 > R1 > R2 > R6.

Ecological Value Characteristics of the Tested Resources

During the GM growth process, there is a certain environmental value in the process of carbon fixation and oxygen production (*Table 1*). The benefit of carbon fixation is 429.19–617.46 USD/hm^2, with an average of approximately 521.34 USD/hm^2, and the benefit of oxygen production is 484.43–696.93 USD/hm^2, with an average of approximately 588.44 USD/hm^2. GM can provide nutrients for the next crop after fresh grass is returned to the field. If nutrients are converted to fertilizer, it is equivalent to

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148.63–209.15 USD urea/hm^2 with an average of 180.87 USD/hm^2, 14.9–32.84 USD calcium magnesium phosphate/hm^2 with an average of 22.99 USD/hm^2, and 181.66-340.56 USD potassium sulfate/hm^2 with an average of 267.91 USD/hm^2. Therefore, from planting to returning to the field, the GM can produce 1275.46–1806.05 USD of total ecological value/hm^2 with an average of 1581.54 USD/hm^2. Specifically, the order of total ecological value was as follows: R2 > R4 > R3 > R5 > R6 > R1, where the values of R2 and R4 are significantly higher than the value of R1, and other differences were not significant.

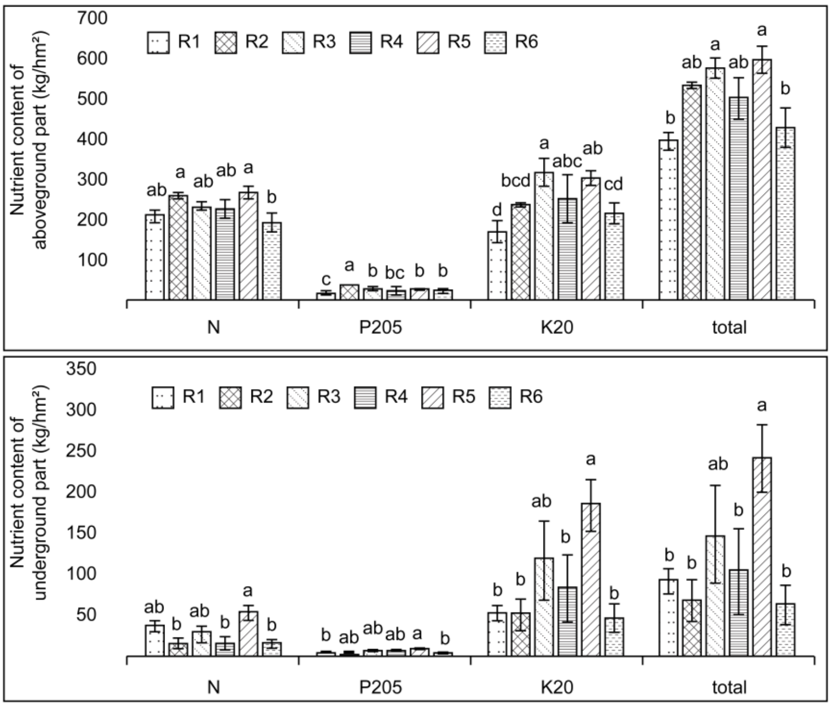

Figure 3. *Content of N, P, and K under different treatments*

Table 1. *Ecological value of green manure under different treatments (USD/hm^2)*

Treatment	Carbon	Oxygen	Urea	Calcium magnesium phosphate	Potassium sulfate	Total value
R1	429.19±26.10	484.43±29.46	165.29±10.05	14.90±0.91	181.66±11.05	1275.46±77.56b
R2	617.46±10.77	696.93±12.15	203.02±3.54	32.84±0.57	255.81±4.46	1806.05±31.50a
R3	513.01±54.90	579.04±61.96	182.21±19.50	24.75±2.65	340.56±36.44	1639.58±175.45ab
R4	611.50±60.12	690.20±67.86	176.90±17.39	19.93±1.96	271.46±26.69	1769.99±174.03a
R5	446.99±26.68	504.52±30.12	209.15±12.48	23.84±1.42	327.30±19.54	1511.80±90.24ab
R6	509.88±61.11	575.50±68.98	148.63±17.81	21.65±2.60	230.66±27.65	1486.33±178.15ab

Note: Carbon (industrial carbon, 0.26 CNY/kg); oxygen (industrial oxygen, 0.4 CNY/kg); urea (N 60%, 2.4 CNY/kg); calcium magnesium phosphate (P_2O_5 15%, 0.9 CNY/kg); potassium sulfate (K_2O 50%,3.6 CNY/kg)

Parameter Determination of the Reference Resources

The parameters of the reference resources are set according to the optimal indices of the characteristics of each tested resource and the ideal target parameters during field

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observation, as shown in *Table 2*. Five indices were selected to indicate the landscape. The total number of flowers, the total flower area, and the flowering period were determined as 2898/m^2, 0.91 m^2/m^2, and 20 days, respectively, which are positive indices, whereas the early flowering period was set as 3.1, which belongs to a reverse index. The mean height of flowers was set as 110 cm, which is considered a neutral index. One index was selected to show the growth of GM, the yield of fresh grass was set as 67 t/hm^2, which is a positive index. Five indices representing the ecological value were selected. The first three were the content of N, P, and K that can be returned to the field; the values were 269, 37, and 317 kg/hm^2, respectively. The remaining two parameters were benefits of carbon sequestration and oxygen production, with values of 617 and 697 USD /hm^2. All five indices were positive indices.

Table 2. *Traits of the reference varieties*

Number	Index	Value	Property	Requirement
K1	Number of flowers (flower/m^2)	2898	Positive	Higher the flower number, the better
K2	Unit area of flower area (m^2/m^2)	0.91	Positive	Bigger the flowers, the better
K3	Flowering period (d)	20	Positive	Longer the flowering period, the better
K4	Date of beginning flowering (month/day)	3.3	Reverse	Earlier the flowering, the better
K5	Flower height (cm)	110	Neutral	Applicable visual
K6	Fresh yield (t/hm^2)	67	Positive	Higher the yield, the better
K7	Nitrogen content (kg/hm^2)	269	Positive	Higher the nitrogen content, the better
K8	Phosphorus content (kg/hm^2)	37	Positive	Higher the phosphorus content, the better
K9	Potassium content (kg/hm^2)	317	Positive	Higher the potassium content, the better
K10	Carbon sequestration (USD/hm^2)	617	Positive	Higher the carbon sequestration, the better
K11	Oxygen production (USD/hm^2)	697	Positive	Higher the oxygen production, the better

Analysis of Equal Weight Correlation Coefficient

The units used for distinct traits are different; the original data on each trait of the tested resources and the reference resources are first obtained dimensionless, and then the dimensionless results are substituted in the following formula: $\triangle ik=|X_{0k}-X_{ik}|$ (i=1, 2, …6, k=1, 2, …11) to calculate the absolute difference of the corresponding traits of X_{0k} and X_{ik}. The max△ik and min△ik were 0.6484 and 0.0000, respectively; they are substituted into *Eq. 3*; thus, the correlation coefficient of 6 resources and 11 traits of the reference resources are obtained, as shown in *Table 3*. Next, the data in *Table 3* are substituted in *Eq. 4*, and equal weight correlation coefficient between the test resources and ideal reference resources can be obtained, as shown in *Table 5*.

Table 3. *Correlation coefficient of traits between the tested varieties and reference varieties*

Item	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11
ξ1k	0.3741	0.4597	1.0000	0.8642	0.7299	0.6745	0.6055	0.3706	0.4098	0.5154	0.5153
ξ2k	0.4682	0.4670	0.7643	0.7955	0.6021	0.9864	0.9124	0.9727	0.5653	0.9998	1.0000
ξ3k	1.0000	1.0000	0.6185	0.8414	0.7299	0.6277	0.7131	0.5615	0.9982	0.6572	0.6571
ξ4k	0.4035	0.3333	0.6837	0.8502	0.5092	0.5311	0.6755	0.4485	0.6145	0.9713	0.9711
ξ5k	0.4059	0.3758	0.8664	0.8957	0.5732	0.5625	0.9944	0.5359	0.8914	0.5401	0.5401
ξ6k	0.4210	0.4145	0.7643	1.0000	0.5487	0.4594	0.5273	0.4832	0.5008	0.6505	0.6504

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Table 4. *Correlated degree of the tested varieties and reference varieties*

Germplasm No.	Equal-weighted correlative degree		Variation coefficient-weighted correlative degree	
	Correlative degree	**Order**	**Correlative degree**	**Order**
R1	0.5926	5	0.5286	4
R2	0.7758	1	0.7135	2
R3	0.7641	2	0.8030	1
R4	0.6356	4	0.4711	6
R5	0.6529	3	0.5818	3
R6	0.5837	6	0.5214	5

Analysis of Weighted Correlated Degree Based on the Coefficient of Variation

When evaluating the advantages and disadvantages of resources, the purpose of evaluation is different; therefore, the importance of each trait is also different. If only equal weight correlated degree is used for evaluation, it cannot objectively reflect the nature of the tested resources; thus, it is necessary to use the weighted correlated degree ($\triangle\gamma$) for evaluation. Weight can bear different numerical values based on the screening targets and production experience or can be calculated using the coefficient of variation. Using coefficient of variation implies giving weightage in accordance with the degree of variation of the observed values for all evaluated objects. The index with a large degree of variation of the observed values shows that it can better distinguish each scheme in this aspect, and it should be given a larger weight; otherwise, a smaller weight should be given. Therefore, the weight system obtained with this method is determined by the value of observed index variables (Zhang, 2009). In this study, the latter method was adopted, and the coefficient of variation was used to calculate the weight (see *Table 5*). K2, K1, and K5 for the selected landscape indices have a large weight, ranking as the top three; K8 and K9 for the ecological value indices rank fourth and fifth; and K6 for the growth indices ranks sixth. Then, the data of $\xi 1k$ in *Table 3* and the data of ωk in *Table 5* are substituted in *formula (3)* to obtain the weighted correlated degree between the test resources and the reference resources, as shown in *Table 4*.

Table 5. *Coefficient of variation and weight coefficient*

Germplasm No	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11
Variation coefficient	0.3202	0.3688	0.0786	0.0614	0.2746	0.1630	0.1258	0.2593	0.2227	0.1525	0.1525
ωk	0.1469	0.1692	0.0361	0.0282	0.1260	0.0748	0.0577	0.1190	0.1022	0.0700	0.0700
Ranking	2	1	10	11	3	6	9	4	5	8	7

Comprehensive Evaluation and Analysis of the Tested Resources

As shown in *Table 4*, there are differences in the ranking based on equal weight correlated degree of the tested resources and weighted correlated degree of the tested resources. Based on the weight of variation coefficient, we conclude that the weight coefficient of the total flower area, weight coefficient of the number of flowers, and weight coefficient of the mean height of flowers are large. The three indices indicate the size, quantity, and spatial distribution of flowers. The weight coefficient of yield of

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fresh grass is medium. In the indices of GM ecological value, the weight coefficient of P and K that can be returned to the field is large. In terms of equal weight correlation, R2, R3, and R5 rank in the top three, and in terms of weighted correlation, R3, R2, and R5 rank in the top 3. Therefore, it can be concluded that R2, R3, and R5 can be preferentially selected for sightseeing rotational GM cultivation in Guizhou Province.

Discussion

RL belongs to the Cruciferous family of GM crops with a flowering duration that usually starts in early March and ends in early April, lasting 16–20 days. The raceme of RL is terminal inflorescence. Most of the RL flowers are white, and some of them have lines and are cross-shaped. RL has approximately 10–50 flowers per plant, and its height is between 45 and 155 cm. The area of each flower is 2–4.5 cm^2, and the flower area is 43–150 cm^2/plant. The total area of flowers per unit is between 0.28 and 1.12 m^2/m^2 with an average of 0.55 m^2/m^2. In general, RL has a long flowering period and a large number of flowers. The flowers strew randomly, and the tile area is large. The RL flowers can produce a strong visual impression due to the terminal inflorescence, being almost free from the shade of the grass and having high ornamental value. In addition, as a GM crop that has been grown in the south, RL has wide growth adaptability. The yield of fresh grass on the ground is 31.52–68.64 t/hm^2. The fresh grass can be returned to the field for nutritive purposes. Specifically, the N, P, and K content is 145.14–295.10, 14.62–37.73, and 148.56–372.15 kg/hm^2, respectively, and the total nutrient in fresh grass can be returned to the field by 326.74–679.38 kg/hm^2. These stand for high nutrient return benefits, contributing to the quality of the land cultivated by rotation.

It has been reported that the grey correlation analysis overcomes the disadvantage of evaluating varieties solely based on the trait of yield. The method can more comprehensively and accurately reveal the nature of items in extensive and quantitative evaluation of multiple traits. Moreover, the calculation in this analysis is relatively simple and the results are objective and comprehensive. Therefore, it is widely used in the evaluation of rice, wheat, corn, soybean, tobacco, and other crops, and good results have been obtained; therefore, its scope of application is gradually expanding (Zhang et al., 2006; Sun et al., 2010; Song et al., 2011; Zan et al., 2018; Chen et al., 2020). In the comprehensive evaluation of GM, with tourism and ecology as the main technical requirements, 11 observation indices were selected, of which five indices were related to the landscape, namely, the total number of flowers, total flower area, flowering period, early flowering period, and mean height of the flowers and reflecting the number, size, time, and space of the flowers created by the RL landscape. One index represented the growth rate of GM (i.e., the fresh grass yield), which is the basis of resource utilization. Five indices showed the ecological value, including N, P, and K content that can be returned to the field, as well as the benefit of carbon fixation and oxygen generation.

In conclusion, the reference resources should be integrated with the characteristics, such as a large number of flowers, large flowers, appropriate height distribution, early flowering, long flowering period, large yield of fresh grass, nutrient content that can be returned to the field, and high benefit of carbon fixation and oxygen production. In addition, by utilizing the coefficient of GM crops to distinguish the importance of different traits to obtain weighted weight, more intuitive and objective evaluation results

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can be obtained from the weight coefficients. With reference to the weight coefficients, K2, K1, and K5 are ranked in the top three, as landscape indicators; K8 and K9 are ranked fourth and fifth as ecological value indicators, and K6 is ranked sixth as a growth indicator. It can be concluded that the actual production corresponds to expectations, and the results can objectively represent the importance of the indicators. Other researchers have found that season, color difference, and plant shape account for a large proportion of plant landscape evaluation factors (Wang, 2021). Furthermore, some researchers believe that the ornamental characteristics of plants have the greatest effect on plant landscape (Liang et al., 2020). The analytic hierarchy process (AHP) has been used to build an evaluation model, and the weight of evaluation indicators and their importance ranking have been obtained: aesthetic function (0.5396) > service function (0.2970) > growth status (0.1634), indicating that aesthetics appeal first visually in the evaluation of plant landscape (Zheng et al., 2021).

Conclusions

RL has both tourism attraction aspect and ecological function; thus, it can be planted from March to April to create a white flower field (see *Figure 4*), which promotes both agriculture and tourism. The utilization of different resources can be based on the flowering time and plant height. It is noteworthy that R6 blossoms the earliest and R5 the last; in terms of height, R1 is the tallest, with R4 and R6 being the shortest. In addition, good quality resources can be selected according to the comprehensive evaluation. However, distinct resources have different traits; each has its own advantages in certain indicators, and a trade-off relationship between traits causes some difficulties in broad assessments. Therefore, a detailed evaluation of resources was carried out using the grey correlation analysis method in selecting purposive and representative character indices, setting the parameters of reference resources, and calculating the weight based on the coefficient of variation. Among the tested resources, R3, R2, and R5 were ranked the highest, and they can be preferentially selected and utilized in ecotourism in Guizhou Province. With regard to the flowering period, the three varieties began to blossom in early, mid-to-early, and mid-to-late March, respectively. We have planned research on mixed sowing and utilization of the three resources as a next step to prolong the flowering period of RL.

Figure 4. *Representative photograph of Raphanus sativus L. in the field*

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