



Exploration and application of agriculture-tourism technologies based on rape flowers in rural revitalization of China



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ABSTRACT

Oilseed rape is an ideal model crop of great significance for research on agriculture-tourism integration and multi-functional development of agriculture. This paper explores the application of technologies for agricultural tourism based on rape flowers in rural revitalization of China. It includes perspectives of technologies for colorful rape flowers, flowering time regulation, multi-season blooming and farm landscape, aiming to further utilize the industrial potential of the multiple functions of agricultural crops, and promote the development of agriculture and rural economy to serve the strategic need of rural revitalization in China.

Oilseed rape is one of the most important oil crops in China with a planting area of nearly 6.7 million hectares. Its production is of great significance for ensuring the safe supply of edible oil in China (Wang, 2018). However, in recent years, its planting area has been gradually declining due to low benefits and high labor cost, which has become a great bottleneck restricting the development of rapeseed industry in China. With changes in international trade and the price adjustment of domestic agricultural products, imported oilseeds and vegetable oils have gradually gained more market shares in China, resulting in growing dependence on foreign countries. Moreover, the import has caused great impacts on domestic price of oilseeds and rapeseed oil, thereby largely impeding the development of rapeseed industry in China. Therefore, promotion of the planting benefits of rapeseed and planting area is of great significant to domestic rapeseed industry development and supply safety (Liu et al., 2019).

With agricultural structure adjustment and rapid development of tourism in China, agriculture-tourism integration is becoming an important driving force to solve the problem in agricultural development by optimizing industrial structure and promoting the sustainable development of socially and economically underdeveloped areas (Liu et al., 2019). Since the 19th National Congress of the Communist Party, China's rural area has entered into a new era of overall revitalization and reform. Promotion of agriculture-tourism integration is critical to further implementation of rural revitalization, agriculture transformation and upgrading, and increase of farmers' income. However, previous research on agriculture-tourism integration has been mainly focused on theories

and policies concerning concept, driving force, pattern and empirical studies (Zhu, 2016). Few studies have been focused on the agriculture-tourism integration from the perspective of agricultural industry technology.

Data from the "Report of Flower Tour Tendency of Residents in 2019" issued by the Tongcheng Tourism Group showed that rape flower ranks the second in all tour flowers in the spring. Rape flower tour also greatly promotes local industries, including homestay, catering service, hotels and sale of agricultural and sideline products, exhibiting increasingly stronger driving effects on local economy. In Wuyuan (Jiangxi Province), Hanzhong (Shaanxi Province) and Xinghua (Jiangsu Province), rapeseed industry has become the engine and even pillar of local economic development. In 2019, the comprehensive benefits from rape flower tour reached 6.3 billion CNY in Wuyuan County, accounting for nearly 40% of the annual total GDP of the whole county. Therefore, it is urgent to take full advantage of rapeseed planting benefits and its functions in driving landscape development and industry, as well as establish the special industry mode (all-region layout, full-value-chain exploration and full-industrial-chain development) of rural revitalization (Wang, 2018), which will promote the rural revitalization based on crop agriculture-tourism technologies, promote multiple utilization of crops and agriculture-tourism integration technology development, and facilitate agricultural development and economy. This paper explores the application of crop agriculture-tourism technologies in rural revitalization by taking rapeseed as an example.

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1. Overview of rape flower tourism

1.1. Landscape of colorful rape flower

Breeding technologies of colorful rape flowers could artificially select and breed rapeseed varieties with various colors (such as white, red, purple and orange), which are different from the traditional yellow rape flower. The earliest genetic research in the world on the flower color of rapeseed might be traced back to 1927 (Sylvén, 1927). The earliest relevant research in China could be traced back to the 1980s (Liu, 1983). In terms of variety selection and breeding of rapeseed flowers for landscape, it was only started 3–5 years ago, by research groups from the Oil Crops Research Institute (Chinese Academy of Agricultural Sciences), Huazhong Agricultural University, Sichuan Academy of Agricultural Sciences, Jiangxi Agricultural University, and Guizhou Oil Crops Research Institute.

Resources of colorful flower rape are mainly derived from natural variations, artificially physiochemically induced mutations and distant hybridization (Chen et al., 2019). The genetically close species in *Brassica* genus of the Cruciferae family have abundant flower colors, including *Raphanus sativus*, *Corychophramus Violaceua*, *Matthiola incana*, *Cheiranthus cheiri* and *Malcolmia Africana*. Therefore, distant hybridization is becoming the main method to obtain colorful rape flowers at present. Moreover, some researchers have attempted to develop rapeseed cultivars with both colorful flowers and high yield/quality of oilseeds with modern breeding technologies. So far, there are 40–50 rape varieties with different colors from different institutes and sources (Chen et al., 2019; Zhang et al., 2000). However, no more than 10 colors (orange yellow, milk white, yellow white, light red, and purple red) have been applied to produce stable flower color and good plant architecture. The main reasons are inadequate brightness of the flower color and flower amount. Lower brightness and flower amounts might be unique and attractive for short-distance appreciation, but not suitable for long-distance and overall appreciation. Therefore, the visual effect remains to be promoted.

Eight rape flowers are shown in Fig. 1, including the main flower colors often applied in landscape. Cultivars (or lines) with colorful flowers such as white and orange have relatively bright color, which contributes to a better visual effect. Moreover, a kind of purple-leaved rapeseed is also often used in production, which becomes a foliage plant due its fewer flowers.

1.2. Technologies for regulating flowering time of rapeseed

Blooming time and flowering duration are both important for

landscape. Previous research has been mainly focused on regulation of blooming time of rapeseed from the perspectives of breeding and molecular research. However, the regulation of flowering duration is even more important for rape flowers in agricultural tourism. Particularly, technologies to prolong the flowering duration for booming rape flower tour in recent years are of great significance for benefit improvements in scenic areas. Taking Huangling in Wuyuan (in Jiangxi Province) as an example, the tour ticket is 140 CNY per visitor. Averagely, about 25,000 tourists visit the scenic site each day. If the flowering duration could be extended for 10 more days, the ticket sales might bring a 35,000,000 CNY increase as the income of the area. Regretfully, current research on flowering duration regulation is mainly focused on horticultural and garden flowers, and more research is needed on rapeseed (Zhu et al., 2017).

Some explorations have been made on rapeseed variety selection and breeding, cultivation management, hormone regulation and gene expression, but the effects are still unsatisfactory. According to the approaches used, these explorations could be classified into cultivation measures and regulation with growth regulators. The cultivation measures mainly include mixed sowing, and thin planting + fertilizer and water management + stalk pinching; the former prolongs the flowering duration by sowing rapeseed varieties with early and late maturity in a mixed way at certain proportions; while the latter prolongs the flowering duration by increasing the branching of rapeseed plants through thin planting, stalk pinching and improved management of fertilizer and water. In terms of chemical regulation, Zhu et al. (2017) proposed that the combination of heteroauxin and IAA + growth retardants could prolong the flowering duration.

1.3. Technologies for four-season rape flowering

Rapeseed can bloom at four seasons under appropriate technical control. For the development of rape flower tour, and to solve the problems of short blooming duration and strong seasonality, the Oil Crops Research Institute (Chinese Academy of Agricultural Sciences) has successfully developed a technology for four-season rape flowering, which has been applied in Wuyuan in 2019 (Fig. 2). This technology could realize rape blooming under daily mean temperature above 5 °C at different seasons, contributing to both rape flower landscape and harvest of oilseeds. This technology consists of the following techniques: cultivar meteorological fitting analysis, seed pretreatment before germination, even and full seedlings after dry sowing, early germination and stronger plants under middle and high temperature, regulation of the three elements of rape flower landscape (flower color, blooming time and flowering amount), comprehensive management/control of fertilizer and



Fig. 1. Rape flowers with different colors.



Fig. 2. Rape flowers blooming in Autumn\traditional sowing season (Jiangxi Wuyuan, October 2019).

water, and green prevention/control of pests and diseases. To some extent, this technology could solve the problems such as weak plants, difficult blooming, bleak flowers, short flowering duration and small petals under high temperature in the summer. It can break the seasonal limitation of rape flower tour, and realize custom-built flowering time and duration in a certain range according to the tour demand. This technology paves a new way for the development of agriculture-tourism integration in rapeseed, and is of great significance for the south- and north-ward expansion of rapeseed planting area in China.

1.4. Technologies for creative farmland landscape

Creative landscape farmland not only has artistic visual effect, but also provides agricultural products (Zhang, 2021). The technologies involve the assessment of land types, crops (field crops, vegetables and herb medicines) coordination and application of planning theories (such as landscape aesthetics, landscape ecology and agricultural ecology), then transforming farmland with artistic and technical approaches based on planting forms and plant colors.

Creative farmland landscape utilizes the rich colors of field crops, including white-leafed rice, yellow-leafed rice, purple-leafed rice, yellow-flowered rapeseed, white-flowered rapeseed, and artistically designs and collocates colors of agricultural crops, by gridding and coordinate setting with GPS Total Station, resulting in landscape design with both productivity and artistry (Li and Liu, 2020; Wang, 2019). The collocation of rape flowers with other crops (rice and wheat for instance) could create an art design in field (Fig. 3). As an example, Fig. 3 shows the application of creative farmland landscape in Songzi and Shayang of Hubei Province. The creation of art design with rape flowers is mainly in reference to the Rice Paddy Art. The Rice Paddy Art originated from Japan, which could present pre-designed patterns in rice paddy fields through cross sowing and intercropping, achieving “different sceneries in

four seasons” by changes in color in different crop growth stages.

A. Rape flower scenery in Weishui Town of Songzi, Hubei Province; B. Rape flower scenery in Wuhan, Hubei Province.

2. Application of rape flower tourism in rural revitalization

2.1. Rape flower sea based on natural resources

Currently, the well-developed destinations for rape flower tour are generally based on the rape flowers from natural resources, mainly including Wuyuan (in Jiangxi Province), Menyuan (in Qinghai Province), Xinghua (in Jiangsu Province), and Luoping (in Yunnan Province). Wuyuan is mainly characterized by the beautiful scenery, composed of rape flowers in terraced fields and “white wall and black tiles” cultural landscape. Duotian rape flower scenery in Xinghua is constituted by the special Duotian scenery in wetland and all-standing rape flowers.

Various tourism activities, such as festivals of rape flower, have greatly promoted the production of rapeseed and tourism economy. The Tourism Festival of Rape Flowers has been consecutively held in Shayang, Hubei Province for 13 years, and the annual tourists and comprehensive tourism income have risen from 100 thousand tourists and 200 million CNY in 2008 to 2.95 million tourists and 1.34 billion CNY in 2019. According to the statistics of Rapeseed Office in Hubei Province, about 65 thousand hectares rapeseed field has been developed into tourist sites in 2020, accounting for nearly 6% of the total rapeseed planting area. Rape flower tour has contributed greatly to the tourism economy of many regions.

2.2. Application of colorful rape flowers in flower tour

Colorful rape flowers have been used as important supplements in many flower scenic sites to make special scenery to attract tourists. For example, in Hanzhong of Shaanxi Province, Zhangchi Village of Shayang in Hubei Province, Xiaosi Town of Caidian in Wuhan, colorful rape flowers are used as ornament in rape flower sea attractions. Some farms, homestays and planting cooperatives prefer to plant colorful rape to attract more consumers. However, the marketed seeds of colorful flower rapes are generally priced at 800–1600 CNY/kg currently. The high price has largely hindered its planting scale. According to preliminary estimation, only about 4–5 tons of colorful rape seeds are used in each year in China, which could be planted on 667 ha. Most colorful rape flowers are used for intercropping with different color flowers to form rare rape flower scenery so as to attract tourists, and others are combined with creative farmland landscape in special designs.

2.3. Application of four-season rape flowering technology

Four-season rape flowering has received great attention from several regions and scenic areas, because it breaks the one-season planting mode



Fig. 3. Application of creative farmland landscape in Hubei Province.

of rapeseed by controlling the flowering time according to actual needs. Since 2019, the technology has been popularized and applied in more than 10 regions, including Wuyuan (in Jiangxi Province), Wuhan and Songzi (in Hubei Province), Xinghua (in Jiangsu Province), and Xi'an (in Shaanxi Province). The total planting area has reached nearly 133 ha, which greatly contributes to local tourism and economy promotion. In some areas, this technology helps to create rape flower scenery for two or three times in one year, which significantly promotes the benefits of agricultural tourism. These changes have helped the transformation and upgrading of “one-season flower tourism” to “full-season flower tourism” in Wuyuan. According to the estimation of the Tourism Bureau of Wuyuan, four-season rape flowering attracted about 600 thousand tourists in 2019–2020, bringing about 11 million CNY economic benefits, and contributing nearly 300 million CNY to comprehensive output of Wuyuan. This technology also realizes the north-ward expansion of rapeseed planting, promoting the increase in rapeseed planting area. For example, customized planting of rapeseed was implemented in Quyang County (in Hebei Province) in 2021 for the ‘5.15 Rape flower Festival’ (on May 15th), realizing good comprehensive application and development of both flowers and oil production.

2.4. Application of creative farmland landscape technology

Creative farmland landscape technology has been widely applied in various crops such as wheat, rice and rapeseed in China. The well-known creative farmland landscapes include circles in wheat fields, and labyrinths in maize, tea and rapeseed fields. In China, agricultural fields landscape arts in many areas are very creative, such as the large rice paddy art composed of “Flying Apsaras”, “Sea Waves”, and “Shark” in Yili (in Xinjiang Province), the large rice paddy art “Good Life in China” in the Xibozu Town of Shenyang (in Liaoning Province), and the rice paddy art “Mickey Mouse” in the Disneyland of Shanghai, the rapeseed field arts of “Thousand Years of Libai, a Return to the Earth” in Jiangyou (in Sichuan Province), the giant farmland landscapes of “the Silk Road” in Shanghai and “Dragon Robe” in Nanjing (in Jiangsu Province) which are created by rapeseed. Rape flowers have greatly facilitated the development of local economy in China's rural areas.

New sustainable development modes of agricultural tourism have been established in some areas through integration of resources of color farmland landscape, creative landscape and network marketing (Li et al., 2021). In 2016, to popularize the agricultural e-commerce “Let Me Be Online”, a creative advertisement was established by building a farmland landscape of a 1.33 ha QR code in the thousands mu of rape flowers in Tiankai Flower Sea, which facilitates the development of new modes of creative landscape planting with productization of farmland. In addition, the landscape pattern of farmland can also influence the diversity of birds and natural enemy insects, and plays certain roles in controlling the pests. For example, Jiang et al. revealed that the farmland landscape with about 20% of non-maize habitat could accommodate more natural enemy insects and reduce the occurrence of corn leaf aphids, and promote biological control effect of farm landscape on maize pests (Jiang et al., 2021).

2.5. Application of multiple functions of rapeseed

Currently, sprouts, flowering stalk, green manure and silage of rapeseed have shown great advantages in development. Researchers found that rapeseed sprouts and flowering stalk have rich nutrients and good taste as vegetables. Rapeseed green manure could promote soil organic matter and has special functions of bacterial inhibition and sterilization (Qin et al., 2021). Rapeseed silage can improve animals' meat quality and goats' fertility (Yang et al., 2017; Zhao et al., 2020). Particularly, “high selenium (Se) efficiency” vegetable rapeseed hybrid “Xiziyuan No.1” was successfully bred, which shows strong ability of selenium accumulation. Planting in multiple non-selenium-rich locations in China has generated high-Se flowering stalks, which also have high

calcium (Ca), vitamin C, amino acids and zinc (Zn) content, as well as rich nutrients, green color, crispy taste, and even great potential in medicine for health care (Liu et al., 2020). As for the tourism product exploitation, various derivative products of rape flowers have been exploited, such as flower tea, flower liquor, flower biscuit and facial mask with rape flower extract.

3. Prospects of rape flower tourism

3.1. Technical problems in rape flower tourism

The rape flower tourism in China is still at the preliminary developmental stage, which is mainly driven by the market. Particularly, the building of rape flower sea is mainly dependent on the current rapeseed planting and publicity of the local resources, while the potential of rape flower tourism remains to be further developed, and the design is still not systematic (Cheng and Liu, 2018). Some techniques, such as mixed sowing and regulation with growth regulators, are still at the experimental stage, and there has been no publication about their actual application.

However, with increasingly important role of rape flower tourism in driving local economy, particularly with the booming of rape flower tourism in some areas, the technical problems have become more prominent due to homogenization degree and competition among different scenic sites. The problems mainly include technical defects, short flowering duration, inadequate brightness of flower colors, strong seasonality, insufficient integration between agriculture and tourism, rough techniques and modes of tourism, mismatch between agricultural techniques and tourism concept, incoordination between techniques, lack of systematic research, poor assembly of landscape design, agronomic planting, multi-function utilization and industrial integration, lack of independent and systematic agriculture-tourism technical integration mode, and incoordination between market and rape flower tourism techniques. All these problems have great negative effects, which need to be overcome in further development of rape flower tourism in China.

3.2. Prospect of rape flower tourism

Rape flower tour has a significant promotion effect on planting benefits of rapeseed for farmer households in China. Agriculture-tourism integration is an important pathway to promote the rural revitalization (Li et al., 2022). As the largest planting oil crop in China, rapeseed can be used as vegetable, fertilizer, silage, medicine and honey source, and is one of the most popular sources of flower tour as well. It is the most ideal “model crop” to be used in agricultural tourism due to its characteristics of diversified varieties, strong adaptability, and wide distribution. Hence, further research on rape flower tour might provide technical support and important reference for the agriculture-tourism integration of other crops.

Moreover, in terms of rape flower economy, with increasing importance of rape flower tourism, there will be increasing demand for relevant techniques. Particularly under rural revitalization and development of rural industry by utilizing the multiple functions of agriculture, it is necessary to consider the techniques for rape flower tourism as a relatively independent discipline in research. Therefore, under the prerequisite of ensuring food safety and effective supply of important agricultural products, it is highly necessary to further mine the multiple functions of rapeseed including landscape, and establish intelligentized, informationized, standardized and specialized modes, so as to promote the solid supply of food, transformation of ecological conservation, and extension of the leisure and cultural inheritance functions of agriculture for the high-quality and high-efficiency development of agriculture in China.

4. Summary

Agriculture revitalization is the core of rural revitalization. Currently,

it is obvious that traditional planting cannot meet the demand of farmers for benefits, and therefore the benefits and modes should be completely transformed. Benefits from multiple functions of special crops in regions, such as planting, tourism, ecology and culture, should be fully utilized to promote the transformation, upgrading and full revitalization of agriculture and rural areas. Taking rapeseed as an example, quality and efficiency should be promoted by improving varieties, cultivation measures, and fully-mechanized process. Then, the benefits from agriculture-tourism integration of rape flower should be fully considered, and further efforts should be made to promote the upgrade of rape flower tour economy. The strategies might include integration of local cultural tradition elements with existing spontaneous scenic areas and natural resources. Modern design of agriculture-tourism should be introduced to create a featured, active, specialized and high-benefit agriculture-tourism integration mode. Important driving effects of rape flower tour on other industries should be integrated as well. Rape flower tour can help to improve other local industries such as tea, rice, vegetable and fruit, as well as the potential value of rapeseed itself, including canola oil, vegetable flowering stalk, tea, liquor, cosmetics, perfume, medicine, and health care products.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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