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Current Situations of Development and Use of Wild Vegetables in Yichun Area and Recommendations

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Abstract Based on the survey on wild plants in 21 counties (cities) in Yichun Area, 89 species of 32 families of wild vegetables were collected. The species, parts, edible parts, distribution and current development and use of wild vegetables in Yichun Area were expounded. Then, existing problems of wild vegetables in Yichun Area were discussed. Finally, pertinent recommendations were put forward.

Key words Yichun Area, Wild vegetables, Development and use

1 Introduction

Wild vegetables grow in wild fields where the environment is excellent and free from pollution of modern industry, pesticides and chemical fertilizers. Characterized by fresh, green, and wild shape, and nutritious, medicinal, and tasty features, wild vegetables are reputed as organic green food, and deeply favored by people. Since the 1980s, with the rapid economic development, the improvement trade for export has been constantly increasing. At the same time, resources of wild vegetables in Xiaoxing'anling are also developing rapidly, and collection of wild vegetables has become an essential part of economic income of workers in forest region. However, due to the long-term disorderly and predatory collection of wild vegetables, original habitat of wild vegetables is greatly damaged, and the distribution density and range are declining year by year. In addition, under the influence of resource situation, processing level and disorderly competition, the processing of wild vegetables fails to become strong, and gifted resource advantages fail to bring the expected economic and social benefits. In this situation, the Agricultural Technology Research and Extension Center of Yichun City, taking processing of wild vegetables and farmers' market as survey objects, surveyed current situations of development and use of wild vegetables, and finally came up with recommendations.

2 Overview of the survey of wild vegetables

2.1 Species of wild vegetables In Yichun Area, a total of 89 species of 32 families of wild vegetables have been identified (as shown in Table 1), among which 35 species have been accepted, accounting for 39.3%, while the rest 54 species are edible but have not been accepted by the public. In those species accepted by the public, the rate of both processing and utilization is high, 11 species have high market share, such as *Allium victorialis* L., *Osmunda japonica*, *Pteridium aquilinum*, *Athyrium multidentatum*, *Matteuccia struthiopteris* (L.) Todaro, *Aralia elata* (Miq.)

Seem., *heracleum moellendorffii*, *Taraxacum mongolicum* Hand.-Mazz., *Hemerocallis citrine*. Other 24 species are only limited to self-collection and self-eating, and local circulation, such as *Artemisia integrifolia* Linn., *Capsella bursa-pastoris*, *Aegopodium alpestre* Ledeb., *Chenopodium album*, *Portulaca oleracea* L.

2.1.1 Formation of wild vegetables in Yichun Area. Among the 89 species of edible wild vegetable plants, there are 5 kinds of *Pteridophyte* belonging to 5 families, and the rest are angiosperms having absolute dominance. In angiosperms, there are 19 species of *Asteraceae*, 6 species of *cruciferae* and *Labiataeae* respectively, 5 species of *Ranunculaceae* and *Polygonaceae* respectively, 4 species of *Umbelliferae*, *Chenopodiaceae*, *Liliaceae* and *Rosaceae* respectively, 3 species of *Caryophyllaceae* and *Campanulaceae* respectively, and 1–2 species for the remaining families. *Asteraceae*, *Cruciferae* and *Labiatae* vegetables are important parts of wild vegetables in Yichun Area (as listed in Table 2).

2.1.2 Edible parts of wild vegetables in Yichun Area. According to the edible parts, plant organs, and picking habit of the wild vegetables (repeated statistics were made for wild vegetables with two or more edible parts), wild vegetables are divided into seedling type, sprout type, stem and leaf type, root type, flower type, fruit type, and fern type. Seedling type wild vegetables: wild vegetables with seedlings or tender seedlings as edible parts, 55 species in total, accounting for 62.5%, such as *Urtica angustifolia*, *Taraxacum mongolicum* Hand.-Mazz., and *Leersuderionlolo*. Sprout type wild vegetables: wild vegetables with sprouts as edible parts, only 3 species, accounting for 3.5%, such as *Aralia elata* (Miq.) Seem. and *Berberis* spp. Stem and leaf type wild vegetables: wild vegetables with tender stems, leaves, and leafstalks as edible parts, 15 species in total, accounting for 15.9%, such as *Monochoria vaginalis*, *Sonchus arvensis*, and *Mentha*. Root type wild vegetables: wild vegetables with roots and underground twisted organs as edible parts, 6 species in total, accounting for 6.8%, such as *Platycodon grandiflorus*, *Arctium lappa*, *Adenophora tetraphylla*, and *Lilium distichum*. Flower type wild vegetables: wild vegetables with flowers and inflorescence as edible parts, 4 species in total, including *Rosa acicularis* and *Hemerocal-*

lis fulva. Fruit type wild vegetables: wild vegetable with fruits or seeds as edible parts, only one species, *Ulmus pumila* L. Fern type wild vegetables: wild vegetables with buds or tender buds as edible parts, 5 species in total, accounting for 5.6%, such as *Pteridium aquilinum* var. *latiusculum*, *Equisetum arvense*, *Athyrium multidentatum*, and *Osmunda cinnamomea*, as listed in Table 1.

Table 1 Species of wild vegetables divided by edible parts

Edible parts	Quantity of species	Percentage//%
Seedlings	55	62.5
Sprouts	3	3.5
Stems and leaves	15	15.9
Roots	6	6.8
Flowers	4	4.5
Fruits	1	1.2
Ferns	5	5.6

2.2 Natural growth and distribution rules of wild vegetables

Wild vegetables naturally grow in the mountains, edge of forest, groves, farmland, road side, valleys, ditch side, river banks, etc. In different natural growth environment, there are different wild vegetables. In farmland, homestead side, road side, wasteland, and grassy slope, there are *Taraxacum mongolicum* Hand.-Mazz., *Leersuderivolo*, *Amaranthus dubius*, *Cleome gynandra*, *Portulaca oleracea*, *Allium macrostemon* Bunge; in river banks and valley sides, there are *Artemisiainegrifolia*, *Pteridium aquilinum* var. *latiusculum*, and *Commelina communis*; in edge of forest, sparse woods and under forest, there are various *Viola verecunda*, *Cimicifuga foetida* L., *Doellingeria scaber*, *Aster tataricus*, etc.; under broad leaf forest, there are various *Viola verecunda*, *Adenophora stricta*, *Cimicifuga foetida* L., and *Eleutherococcus senticosus*; under mixed broadleaf-conifer forest, there are *heracleum moellendorffii*, *Parasenecio hastatus*, *Pteridium aquilinum* var. *latiusculum*, *Osmunda cinnamomea* L. var. *asiatica*. Situated in the hinterland of Xiaoxing'anling, Yichun Area has a large span from north to south, and distinct changes in temperature, precipitation, forest, soil and other conditions, leading to significant difference in horizontal ecological environment and obvious natural distribution pattern of wild vegetables in this area. We surveyed distribution of staple wild vegetables such as *Pteridium aquilinum* var. *latiusculum*, *Athyrium brevifrons*, *Osmunda cinnamomea* L., *Heracleum moellendorffii*, *Aralia elata* Seem, *Eleutherococcus senticosus*, *Allium victorialis*; all areas of Yichun area have distribution of *Pteridium aquilinum* var. *latiusculum*, *Athyrium brevifrons*, and *Heracleum moellendorffii*, while *Osmunda cinnamomea* L. is mainly distributed in Jiayin County, Xinqing District, and Tangwanghe District. *Allium victorialis* L. is mainly distributed in Wuyiling District, Tangwanghe District, and Youhao District, and partly distributed in Shuangfeng forest area. *Petasites palmatus* is mainly distributed in Wuhema District and Cuiluan District.

2.3 Collection season of wild vegetables Every kind of wild vegetable has the most suitable edible period. Thus, wild vegetables collected in this period have the best quality, largest quantity, and highest commodity value. Currently, 35 wild vegetables

are widely eaten, fern type, sprout type and fruit type wild vegetables should be collected in spring. Seedling type and stem and leaf type vegetables can be collected in spring, summer, and autumn, but the quality is highest in spring, general in autumn, and low in summer. Root type vegetables are mainly collected in the autumn because in this period the fruit becomes rape, nutritious substances are accumulated in roots and tubers. Root type vegetables may also be collected in winter and spring. Flower type wild vegetables can be collected in summer and autumn. In practice, collection may be carried out in accordance with types combined with phenological period of different areas.

3 Current situations of development and utilization of wild vegetables

3.1 Current situations of collection and utilization of wild vegetables At present, the methods of collection and utilization of wild vegetables are still very primitive and can be roughly divided into three types. The first type is self-collection and self-eating. In this type, wild vegetables collected are various and eaten in fresh form, pickled or salted form, frozen form. The second type is self-collection and self-sale. In this type, people select certain type of wild vegetables and they only collect wild vegetables with best sale and high price. Most of such wild vegetables are digested by restaurants, hotels, and dumpling restaurants, little is sold to tourists or dried or salted and transported to other places. The third type is professional collection. People collecting such type of wild vegetables are called mountain runners. They just collect those wild vegetables in high demand, such as *Allium victorialis*, *Pteridium aquilinum* var. *latiusculum*, *Aralia elata* Seem, and *Eleutherococcus senticosus*. They deliver the collected wild vegetables immediately after collection to purchase sites, and can receive cash directly and obtain high income.

3.2 Current situations of purchase, processing and utilization of enterprises Through survey, wild vegetable processing enterprises are mainly concentrated in Yichun District, Tieli City, Xinqing, Tangwanghe District, and Nancha District, and enterprises engaged in wild vegetables include Shenlin Wild Vegetable Co., Ltd. and Fenglin Speciality Product Co., Ltd. as listed in Table 2. The wild vegetables in demand are *Allium victorialis*, *Eleutherococcus senticosus*, *Athyrium brevifrons*, *Pteridium aquilinum* var. *latiusculum*, *Aralia elata* Seem, *Petasites palmate*, *Gretia*, *Osmunda cinnamomea* L., *Taraxacum*, and *Hemerocallis citrina Baroni*, and the processing methods are mainly fresh keeping, salting or pickling, drying, and tea making. Wild vegetable fresh keeping and drying series have package and brand, and are available in sales windows, monopolized shops, and supermarkets. Fresh and dried wild vegetables have become characteristic agricultural products of Yichun Area. Salted wild vegetables are mainly primary products. Such products are mainly used for trade. There are also orders from dumpling processing enterprises in Tianjin and Shenyang. Through simple packaging, the salted wild vegetables are exported to South Korea, Japan and other Southeast Asian countries through agents in Dalian, Shenyang, and Yanji. In 2016, the collection volume of fresh *Allium victorialis* reached

1500 tons. Through primary salting, *Allium victorialis* was exported to South Korea through Dalian and Qingdao, and becomes famous South Korean pickled vegetable, and becomes the product with high added value. Only one enterprise takes *Eleutherococcus senticosus* and *Taraxacum* as raw material of tea and has realized

high sales. *Passiflora henryi* Hemsl, *Monochoria vaginalis*, and *Urtica fissa* E. Pritz. have high production, but most of them remain at the stage of self-collection and self-eating, and basically no enterprise purchases and processes them, and there is no downstream product.

Table 2 Wild vegetable processing enterprises in Yichun City

No.	Enterprise name	Address	Raw materials of processing	Form of processing	Trademark	Grade of trademark
1	Shenlin Wild Vegetable Co. , Ltd. of Tieli City	Taoshan Forestry Bureau	<i>Pteridium aquilinum</i> var. <i>latiusculum</i> , <i>Athyrium brevifrons</i> , <i>Heracleum moellendorffii</i> , <i>Aralia elata</i> Seem , <i>Eleutherococcus senticosus</i> , <i>Artemisia integrifolia</i> Linn . , <i>Urtica fissa</i> E. Pritz . , <i>Allium victorialis</i>	Salting Fresh keeping Drying	Shenyecai	Famous trademark of the province
2	Fenglin Speciality Product Co. , Ltd. of Yichun City	Yichun District	<i>Pteridium aquilinum</i> var. <i>latiusculum</i> , <i>Athyrium brevifrons</i> , <i>Heracleum moellendorffii</i> , <i>Aralia elata</i> Seem , <i>Eleutherococcus senticosus</i> , <i>Hemerocallis citrina</i> Baroni , <i>Allium victorialis</i>		Fenglin	Famous trademark of China
3	Linhai Wild Food Co. , Ltd. of Yichun City	Xinqing District	<i>Allium victorialis</i> , <i>Aralia elata</i> , <i>Athyrium brevifrons</i> , <i>Matteuccia struthiopteris</i> , <i>Acanthopanax senticosus</i> , <i>Aster subulatus</i> , <i>Pteridium aquilinum</i> var. <i>latiusculum</i> , and <i>Petasites palmatus</i>		Linhai	Famous trademark of the province
4	Jiyuan Wild Vegetable Processing Factory in Nancha District of Yichun City	Nancha District	<i>Aralia elata</i> , <i>Athyrium brevifrons</i> , <i>Matteuccia struthiopteris</i> , <i>Acanthopanax senticosus</i> , <i>Aster subulatus</i> , <i>Pteridium aquilinum</i> var. <i>latiusculum</i>		Hongjiyuan	
5	Wanli Foreign Economy and Trade Co. , Ltd of Yichun City	Tangwanghe	<i>Pteridium aquilinum</i> var. <i>latiusculum</i> and <i>Allium victorialis</i>			
6	Luzhiyuan Speciality Product Co. , Ltd. of Yichun City	Youhao District	<i>Eleutherococcus senticosus</i> and <i>Taraxacum mongolicum</i> Hand. -Mazz.	Tea making	Xianghe	Famous trademark of the province

3.3 Current situations of domestication and cultivation The artificial domestication and cultivation of wild vegetables started early in Yichun City. In the 1980s, there was greenhouse cultivation of *Taraxacum*. The small area greenhouse has developed into large greenhouse off-season cultivation, and the cultivation technology becomes very mature. In 2012, the government of Yichun City set forth the requirement of providing wild vegetables in all four seasons, increasing planting of wild vegetables in Yichun District, Tieli City, Wumahe District, and Cuiluan District. All areas started taking action and mainly cultivated *Taraxacum*, *Artemisia integrifolia* Linn. , *Hemerocallis citrina* Baroni, *Aralia elata* Seem, *Athyrium brevifrons*, only for sales in farm market. In 2014, the Agricultural Technology Research and Extension Center of Yichun City started conducting breeding technology research of spore seedlings of fern type wild vegetables, and popularizing the cultivation of *Pteridium aquilinum* var. *latiusculum*, *Athyrium brevifrons*, *Matteuccia struthiopteris*, and *Osmunda cinnamomea*. Now, the cultivation area of *Pteridium aquilinum* var. *latiusculum* is up to 100 mu in Nancha District and the cultivation area of *Osmunda cinnamomea* is up to 500 mu in Xinqing District.

3.4 Current situations of scientific and technological researches Scientific research of wild vegetables in Yichun City started late. The foundation is relatively weak, and institutions engaged in research of wild vegetables are limited to Agricultural Technology Research and Extension Center of Yichun City and Academy of

Forestry Sciences of Yichun City. Before 2010, Academy of Forestry Sciences of Yichun City was mainly engaged in fundamental research of distribution, species, and resources of wild vegetables, and Agricultural Technology Research and Extension Center of Yichun City carried out fundamental research of breeding and cultivation technique of *Taraxacum*, *heracleum moellendorffii*, and *Hemerocallis citrine*. After 2012, with close attention of levels of government to the under-forest economic industry, Agricultural Technology Research and Extension Center of Yichun City and Academy of Forestry Sciences of Yichun City strengthened the co-operation with the Northeast Institute of Geography and Agroecology (IGA) of Chinese Academy of Sciences (CAS) and Northeast Forestry University, and introduced three-stage programmed spore breeding technique for fern type wild vegetables, *Aralia chinensis* tissue cultivation and breeding technique.

4 Problems

4.1 Weak protection of wild vegetable resources With people’s understanding of health function of wild vegetables and the commercialization of some wild vegetables, the price of wild vegetables continues rising. Besides, there is no regulation about the collection of wild vegetables. In addition, there is lack of reasonable protection measure. Driven by economic interests, local residents make predatory collection of wild vegetables. Many wild vegetables are destroyed, leading to gradual decrease in stock of some

natural wild vegetables, which is not favorable for sustainable development and commodity development of wild vegetables.

4.2 Low development and utilization rate of wild vegetables

Although there are many kinds of edible wild vegetables, only 35 species are collected by people. In these 35 species, *Allium victorialis* and *Aralia elata* Seem are purchased by enterprises, 24 species including *Monochoria vaginalis*, and *Urtica fissa* E. Pritz. are accepted and sold in small area and basically there is no processing with high added value. 54 species of wild vegetables still remain in the primitive state and their nutrition value and commodity value are not widely accepted. Most precious wild vegetable resources are not developed and utilized, such as *Doellingeria scaber*, *Cleome gynandra*, and *Agastache rugosa*, leading to huge waste of resources. Wild vegetables are highly seasonal. Exceeding certain time, they will lose the food value of become degraded. However, the collection time often conflicts with spring sowing, black edible fungus production, and afforestation. As a result, a large number of wild vegetables are not collected in time.

4.3 Weak scientific and technical innovation ability The scientific research in wild vegetables has just started in recent years. However, it is nearly blank in survey of resource reserves, population productivity, habitat and composition, cultivation techniques, processing technology and preservation technology, especially the application of new high technology. Considering the regional characteristics of wild vegetable resources, it is required to give priority to survey of superior species and resource reserves in different regions, to provide necessary fundamental data for development and utilization of wild vegetables.

4.4 Weak fine and deep processing forces After surveying 16 wild vegetable processing enterprises, we found that 10 enterprises have changed the operating items, the number of wild vegetable processing enterprises are decreasing year by year, which is an indisputable fact. Wild vegetable processing enterprises still use the traditional preservation, salting, pickling, and dry processing methods, resulting in decrease of color, texture, and loss of nutrients of wild vegetables. Species of wild vegetables processed are few and limited to salting, drying, and simple packaging. Besides, production quality lacks unified standard, and product form and taste affect the market value, leading to low price and lack of market competitiveness. In addition, some enterprises are slow in upgrading the processing equipment. Lack of modern processing equipment and technology, efficient streamline operating conditions, they just remain at the low level of primary processing stage. And there are no deep development products such as canned food, beverages, and health care products.

5 Recommendations

5.1 Establishing resource protection base, implementing reasonable development, and ensuring sustainable use Wild vegetables are valuable resources. To ensure the sustainable use of wild vegetables, it is recommended to conduct a general survey on the species, distribution, ecological environment, and reserves of wild vegetables, so as to provide guidance in a macroscopic manner. Development should be based on the protection, focus on

long-term, combine the long term and short term, implement planned development and use, to ensure vegetation restoration and resource regeneration. It is recommended to establish the protection system for wild vegetation resource areas, and formulate appropriate policies and management measures. Development and utilization of wild vegetables should have proper plan, not take predatory collection, to ensure sustainable collection of wild vegetables. In nature, few plants exist separately but combine with other plants. The development of wild vegetables should avoid waste. It is recommended to consider the comprehensive use of fruits, roots, stems, leaves, and flowers. For example, it is recommended to extract edible pigments, flavors, spices, pectin, starch, and sweeteners, to increase the utilization rate of wild vegetables.

5.2 Building scientific research and development team, innovating upon science and technology, to realize comprehensive utilization

The development and utilization of wild vegetables should be carried out on the basis of thorough research. For wild vegetables with good taste, high nutrition, high yield, high demand, and significant benefits, it is recommended to accelerate the research on their artificial domestication and breeding. In particular, it is recommended to research artificial cultivation of rare species. In the process of research, it is necessary to find out demands of natural elements such as fertility, water, light, air, and heat, and rules of diseases and insect pests, to provide basis for development on appropriate scale, pay attention to maintenance of unique taste of wild vegetables and improvement of cultivation measures, to provide scientific basis for development and use of wild vegetables. Besides, it is recommended to strengthen research of nutritional value, medical care value, and food safety of wild vegetables. Many wild vegetables have high nutritional value and significant medical care effect, but not all wild vegetables are directly edible. Some wild vegetables are poisonous, edible and medicinal, and improper eating may cause harm to human body. For example, *Amaranthus tricolor* contains substance sensitive to sunlight. Once eating, people may get disease if exposed to sunlight. It is recommended to strengthen researches of storage and transportation, fresh keeping, and deep processing technologies, and study the support processing equipment.

5.3 Establishing leading enterprise, optimizing the industry, and implementing brand strategy

As the key to the development and expansion of industry, leading enterprise shoulder the responsibility of information guidance, market development, product development, scientific and technological innovation, and serving the industry chain. First, it is recommended to integrate regional resources, establish leading enterprises, optimize allocation of elements, deepen the regional cooperation, conduct deep processing of highly seasonal wild vegetables, such as *Aralia elata* Seem, *Pteridium aquilinum* var. *latiusculum*, *Artemisia integrifolia* Linn., *Monochoria vaginalis*. According to biological characteristics, it is recommended to form many kinds of wild vegetable products including quick frozen, refrigerated, dried, and pickled, to realize sales of wild vegetables in all four seasons. Through supporting and strengthening leading enterprises, extending the industry chain, and keeping close connection, and expanding the indus-

trial scale, it is recommended to avoid disorderly competition and increase the comprehensive benefits. Second, it is recommended to conduct joint development, transform existing processing technologies and improve the management level, and expand the field of deep processing. Third, it is recommended to improve the processing technology and packaging, brand marketing, work out necessary quality standard, strengthen test of product quality, and establish the international standardization system.

5.4 Cultivating the artificial planting mode, expanding the area, and satisfying market demands For wild vegetables with high development value, it is recommended to further study the growth and development rules and requirements for environment, and implement domesticated cultivation. The artificial cultivation affects unique quality characteristics to a certain extent. However, with the demand constantly increasing, it will inevitably lead to exhaustion of wild vegetable resources. Therefore, for some key species, it is recommended to conduct domesticated cultivation of wild vegetables. Wild vegetables have low requirements for growth conditions. It is recommended to use space under forest, edge of forest, farmland, and protected area to plant wild vegetables, to real-

ize sustainable use. Besides, it is recommended to establish large-scale production base, and extend the supply period of wild vegetables in accordance with local situations, to realize the objective of wild vegetables available in all seasons.

References

- [1] LIU CQ, LIU XD, DING ZQ. China (Yichun) color map of forest resources of Xiaoxinganling [M]. Beijing: China Forestry Publishing House, 2011. (in Chinese).
- [2] ZHOU YL. The flora of Heilongjiang Province [M]. Harbin: Northeast Forestry University Press, 1992. (in Chinese).
- [3] ZHANG MP, ZHANG DM. The use of wild vegetable resources in Heilongjiang Province [J]. Journal of Heilongjiang August First Land Reclamation University, 1997, 9(4): 27–29. (in Chinese).
- [4] GE XG, NING W, FAN WL. Ten problems for the development of wild vegetables [J]. China Vegetables, 2004(2): 1–3. (in Chinese).
- [5] ZHAO HT, WANG XH, SHEN YX, *et al.* Sustainable utilization and development of wild vegetables in China [J]. System Sciences and Comprehensive Studies in Agriculture, 2004, 2(2): 300–305. (in Chinese).
- [6] MA KP. Summary of plant resources in Heilongjiang Province [J]. Journal of Qiqihar Junior Teachers' College, 1987(3): 32–37. (in Chinese).
- [7] ZHAO LY, LI ZH, ZHAO HJ, *et al.* Comparison on the difference in soil seed bank between grazed and enclosed grasslands in horqin sandy land [J]. Acta Phytocologica Sinica, 2006, 30(4): 617–623. (in Chinese).
- [8] ZHAO LP, CHENG JM, WAN HE. Research progresses in the soil seed bank [J]. Science of Soil and Water Conservation, 2008, 6(5): 112–118. (in Chinese).
- [9] YIN HJ, CHENG XY, LAI T, *et al.* Seed rain, soil seed bank and seedling regeneration in a 65-year *Picea asperata* plantation in subalpine coniferous, western Sichuan, China [J]. Acta Phytocologica Sinica, 2011, 35(1): 35–44. (in Chinese).
- [10] HUANG ZL, KONG GH, WEI P, *et al.* A preliminary research on the soil seed bank of South Asian tropical forests in different succession stage [J]. Journal of Tropical and Subtropical Botany, 1996, 4(4): 42–49. (in Chinese).
- [11] YANG CH, LI Y, SHAN LS, *et al.* Soil seed bank and natural regeneration potential of *Reaumuria soongorica* Shrubs at different slope positions in Loess Hilly and Gully Region [J]. Bulletin of Soil and Water Conservation, 2016, 36(2): 105–109, 114. (in Chinese).
- [12] BAI WJ, JIAO JY, ZHANG ZG. Effects of soil seed bank on vegetation restoration in abandoned croplands on the hilly-gullied Loess Plateau [J]. Journal of Beijing Forestry University, 2008, 30(4): 65–71. (in Chinese).
- [13] LI YJ, BAO WK, WU FZ. Soil seed bank and natural regeneration potential of shrubland in dry valleys of Minjiang River [J]. Acta Ecologica Sinica, 2010, 30(2): 399–407. (in Chinese).
- [14] LI CM, LONG L, XU CL, *et al.* Characteristics of soil seed banks of alpine meadow under different degradation degrees in Eastern Qilian Mountains [J]. Acta Agrestia Sinica, 2015, 23(5): 957–962. (in Chinese).
- [15] WANG N, JIA YF, BAI WJ, *et al.* The character and dynamics with season of soil seed banks in abandoned croplands of loess gully region [J]. Acta Prataculturae Sinica, 2009, 18(3): 43–52. (in Chinese).
- [16] FACELLI JM, TEMBY AM. Multiple effects of shrubs on annual plant communities in arid lands of South Australia [J]. Austral Ecology, 2002, 27(4): 422–432.
- [17] ZHANG T, HE MZ, CHEN ZP, *et al.* Spatial-temporal dynamics of soil seed banks of heavy metals habitat at wasted lands in drought mining area [J]. Bulletin of Soil and Water Conservation, 2014, 34(4): 296–300, 307. (in Chinese).
- [18] XIA TZ, HUANG JS, LI YQ, *et al.* Review on study progress of soil seed bank [J]. Journal of Mianyang Normal University, 2015, 34(5): 57–62. (in Chinese).
- [19] CHEN XL, WANG GX, YANG Y, *et al.* Seed rain and soil seed bank of *Abies fabri* forests with different ages in Gongga Mountain, Southwest China [J]. Chinese Journal of Ecology, 2013, 32(5): 1141–1147. (in Chinese).
- [20] WANG N, JIA HF, JIAO JY, *et al.* Relationship between persistent soil seed bank and above-ground vegetation on abandoned farmland in An'sai of the North Shaanxi Province [J]. Science of Soil and Water Conservation, 2009, 7(6): 51–57. (in Chinese).

(From page 64)