# Study on the Ground Cover Plant in Tibetan Herb Garden

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**Abstract** This paper conducts a comprehensive survey of the ground cover plant in Tibetan herb garden for the first time using "five-point sampling method". Survey results show that: (i) A total of 46 families, 95 genera, 119 species of ground cover plants in herb garden are applied in Tibet, and *Asteraceae*, *Gramineae*, *Leguminosae*, *Labiatae*, *Iridaceae* and *Liliaceae* are used most, with the species number of 22, 15, 8, 7, 6 and 5, respectively, accounting for 18.49%, 12.61%, 6.72%, 5.88%, 5.04% and 4.20% of the plants surveyed, respectively. (ii) In terms of importance value for the herbaceous layer, the top three plants are *Poa pratensis* L., *Festuca arundinace* and *Lolium multiflorum* L., with the importance value of 45.950, 34.610 and 29.880, respectively; in terms of importance value for the non-turf ground cover herb plants, the top three plants are *Trifolium* L., *Cosmos bipinnata* Cav. and *Althaea rosea* (Linn.) Cavan., with the importance value of 4.372, 3.437 and 2.062, respectively. (iii) The overall level of greening is low and uneven in the region, with large regional differences. In terms of ground cover plant abundance, Nyingchi > Lhasa > Shannan > Changdu > Xigaze > Ali > Nagqu.

**Key words** Herb garden, Ground cover plant, Importance value, Tibet

## 1 Introduction

The ground cover plants in herb garden are the current or perennial plants with underdeveloped xylem of stems, few lignified cells, weak and short herbaceous stem. In a broad sense, they include lawn plants; in a narrow sense, they include the above defined plants except lawn plants[1]. In this paper, the ground cover plants in a broad sense are regarded as the object of study. The ground cover herbaceous plants do not need regular pruning, and have the features of resisting pest and disease and extensive management, in line with the requirements of conservation-oriented landscape, having become one of the development trends of green city[2]. To clearly know the basic situation of ground cover plants in Tibetan herb garden and solve the problems in greening, we use "importance value", Shannon-wiener, Pielou index for quantitative analysis, and make a comprehensive survey of species and application of ground cover plants in Tibetan herb garden for the first time, with a view to providing guidance for landscaping in the region.

## 2 Study area

Tibet is a region on the Tibetan Plateau in Asia, with an area of 1220000 $km^2$. Tibet is the highest region on Earth, with an average elevation of 4900 m. The highest elevation in Tibet is Mount Everest, Earth's highest mountain, rising 8848 m above sea level. Terrain tilts from northwest to southeast, and the terrain is complex and diverse. It is roughly divided into four areas: the north Tibet plateau, the south Tibet valley, east Tibet mountains and valleys, and Himalaya Mountains. It is bitterly cold in winter, with a marked difference in temperature between daytime and night. It features scarce precipitation and a sharp contrast between the dry and wet seasons. It is dry in winter and spring, with frequent occurrence of strong winds, as well as low oxygen content. The climate types from southeast to northwest are tropical zone, subtropical zone, plateau temperate zone, plateau subfrigid zone and plateau frigid zone[3].

## 3 Survey and methods

**3.1 Survey methods** The site survey was conducted on Tibetan 7 cities from June 2014 to September 2015. In the survey area, it is divided into the patch types of park, production, protection, accessory, roads and green space, and the sample plots are set up according to different plant communities. According to the survey point size, using "five-point sampling method", several 1 m × 1 m standard plots are randomly set up respectively in the herbaceous layer for community and diversity investigation[4]. The plot accounts for 0.2‰ of the surveyed urban green space, and the minimum number of plots is not less than 20[5-6]. The information about the name, growth stages, coverage, arrangement model and wild nature of each plant is amply recorded, and the arrangement status of plants is photographed. The canopy density is calculated by eye-measurement[7].

**3.2 Methods** The survey uses the analysis methods for plant community quantitative characteristics to calculate importance value, Simpon index, Shannon-wiener index, Pielou index, growth index, and species abundance index, respectively[8]. The importance value of three types of plants is calculated as follows:

*Importance value = Relative frequency + Relative projected coverage.*

The related index is calculated as follows:

*Species abundance index* $N_0 = S$

*Simpon index* $D = 1 - \sum_{i=1}^{s} (N_i/N)^2]$

*Shannon-wiener index* $H = -\sum N\ln(N_i/N)$

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*Pielou index* $J_{sw} = D/\ln^{s}$

where $N_i$ is the number of species $i$; $N$ is the total number of species; $S$ is the number of species type.

As for the evaluation method for growth index, various vegetative organs of each plant are evaluated according to a certain indicator system, and then the total scores are weighted to determine the health level. It is divided into 5 levels, and the grading standard is shown in Table 1[9-10].

*Growth index* = ( $\sum$ *Number of plants at each level* × *series*) / (*Total number of plants* × *Highest level series*) × 100.

**Table 1 Classification standard of growth index**

| Level | Indicators |
|---|---|
| 0 | Withered leaves and leaves, the whole plant on the brink of death, loss of ornamental value |
| 1 | Weak growth, serious pests and diseases, broken branches and leaves, repugnant to the eye |
| 2 | Good growth, common conditions, occasional pests and diseases or broken branches and leaves, with a certain ornamental value |
| 3 | Good plant form and growth conditions, a small number of pests and diseases, with high ornamental value |
| 4 | Beautiful plant form, strong growth, no pests and diseases, with extremely high ornamental value |

## 4 Survey results and analysis

**4.1 Quantitative characteristics of species** Table 2 shows that there are a total of 119 kinds of herbaceous layer plants. Survey results show that in Tibetan seven cities, the lawn grass is mainly in herbaceous layer, the importance value of *Poa pratensis* L. is highest, and there is serious convergence for the lawn class ground cover plants with importance value in the top five; in the non-lawn class ground cover plants, *Trifolium* L. has the highest importance value. In terms of growth, the artificial turf growth index is generally poor and below 65, while the rural ground cover plant growth index is generally high. In general, for the ground cover plants in Tibetan herb garden, except the lawn grass, the non-lawn ground cover plants are mostly underdeveloped, and they are mainly wild flowers. In terms of relative frequency, *Trifolium* L. > *Medicago sativa* L. > *Hibiscus syriacus* Cavan. > *Melilotus officinalis* > *Potentilla chrysantha* Trev. > *Astragalus strictus* R. Grah. ex Benth. > *Senecio scandens* Buch.-Ham. ex D. Don. In terms of relative frequency, the main artificial flora ground cover plants are in the order of *Cosmos bipinnata* Cav. > *Althaea rosea* (Linn.) Cavan. > *Tagetes patula* L. > *Calendula officinalis* L. They are common in the artificial flower beds, and can not form the landscape effect of multifarious ground cover plant species with high ornamental value.

**Table 2 The characteristics statistics of ground cover plant species in Tibetan herb garden**

| No. | Botanical name | Frequency | Growth index | Relative frequency | Relative coverage | Importance value |
|---|---|---|---|---|---|---|
| 1 | *Poa pratensis* L. | 359 | 60.17 | 22.510 | 23.440 | 45.950 |
| 2 | *Festuca elata* Keng ex E. Alexeev | 284 | 61.24 | 17.810 | 16.800 | 34.610 |
| 3 | *Lolium multiflorum* Lamk. | 67 | 54.93 | 4.201 | 25.680 | 29.880 |
| 4 | *Poa alpigena* Lindm. | 116 | 60.89 | 7.273 | 8.544 | 15.820 |
| 5 | *Lolium perenne* L. | 149 | 52.84 | 9.342 | 4.013 | 13.350 |
| 6 | *Festuca rubra* L. | 92 | 49.87 | 5.768 | 3.505 | 9.273 |
| 7 | *Poa annua* L. | 35 | 50.91 | 2.194 | 2.375 | 4.570 |
| 8 | *Galium odoratum*(L.) Scop. | 27 | 91.85 | 1.693 | 2.679 | 4.372 |
| 9 | *Poa crymophila* Keng | 26 | 62.18 | 1.630 | 2.490 | 4.120 |
| 10 | *Cosmos bipinnata* Cav. | 42 | 91.73 | 2.633 | 0.804 | 3.437 |
| 11 | *Festuca ovina* L. | 21 | 62.80 | 1.317 | 1.908 | 3.224 |
| 12 | *Althaea rosea* Cavan. | 25 | 92.21 | 1.567 | 0.495 | 2.062 |
| 13 | *Eragrostis pilosa* Beauv. | 4 | 82.16 | 0.251 | 1.490 | 1.740 |
| 14 | *Medicago sativa* L. | 15 | 93.23 | 0.940 | 0.580 | 1.520 |
| 15 | *Tagetes patula* L. | 15 | 83.09 | 0.940 | 0.399 | 1.340 |
| 16 | *Calendula officinalis* L. | 18 | 86.64 | 1.129 | 0.0900 | 1.219 |
| 17 | *Poa irrigata* Lindm. | 8 | 79.51 | 0.502 | 0.650 | 1.151 |
| 18 | *Helianthus annuus* | 17 | 89.49 | 1.066 | 0.0800 | 1.146 |
| 19 | *Dahlia pinnata* Cav. | 16 | 88.86 | 1.003 | 0.0800 | 1.083 |
| 20 | *Pennisetum lanatum* Klotz. | 6 | 83.84 | 0.376 | 0.538 | 0.915 |
| 21 | *Hemerocallis fulva* L. | 11 | 83.30 | 0.690 | 0.140 | 0.830 |
| 22 | *Dendranthema morifolium* Tzvel. | 9 | 82.17 | 0.564 | 0.149 | 0.713 |
| 23 | *Melilotus officinalis* | 10 | 88.40 | 0.627 | 0.0730 | 0.700 |
| 24 | *Potentilla chrysantha* Trev. | 8 | 91.53 | 0.502 | 0.152 | 0.653 |
| 25 | *Astragalus strictus* R. Grah. ex Benth. | 8 | 92.96 | 0.502 | 0.117 | 0.618 |

(to be continued)

(continued)

| No. | Botanical name | Frequency | Growth index | Relative frequency | Relative coverage | Importance value |
|---|---|---|---|---|---|---|
| 26 | *Oenothera biennis* L. | 7 | 87.60 | 0.439 | 0.166 | 0.605 |
| 27 | *Senecio scandens* Buch. – Ham. ex D. Don | 8 | 94.72 | 0.502 | 0.0500 | 0.551 |
| 28 | *Dahlia pinnate* cv. | 8 | 86.12 | 0.502 | 0.0390 | 0.541 |
| 29 | *Tropaeolum majus* L. | 8 | 92.35 | 0.502 | 0.0340 | 0.535 |
| 30 | *Phragmites australis* Trin. ex Steud. | 3 | 87.57 | 0.188 | 0.334 | 0.522 |
| 31 | *Callistephus chinensis* Nees | 7 | 87.65 | 0.439 | 0.0180 | 0.457 |
| 32 | *Hibiscus syriacus* Cavan. | 6 | 93.20 | 0.376 | 0.0200 | 0.397 |
| 33 | *Nelumbo nucifera* | 5 | 92.36 | 0.313 | 0.0640 | 0.377 |
| 34 | *Petunia hybrida* Vilm. | 5 | 82.22 | 0.313 | 0.0430 | 0.356 |
| 35 | *Iris potaninii* | 5 | 92.23 | 0.313 | 0.0410 | 0.354 |
| 36 | *Sonchus arvensis* L. | 1 | 91.19 | 0.0630 | 0.278 | 0.341 |
| 37 | *Matthiola incana* | 5 | 93.62 | 0.313 | 0.0140 | 0.327 |
| 38 | *Iris tectorum* | 4 | 76.84 | 0.251 | 0.0760 | 0.326 |
| 39 | *Pelargonium hortorum* Bailey | 5 | 88.13 | 0.313 | 0.0130 | 0.326 |
| 40 | *Calystegia hederacea* Wall. ex. Roxb | 5 | 93.21 | 0.313 | 0.0110 | 0.325 |
| 41 | *Iris lactea Pall.* var. chinensis Koidz. | 4 | 82.41 | 0.251 | 0.0630 | 0.314 |
| 42 | *Antirrhinum majus* L. | 4 | 88.12 | 0.251 | 0.0469 | 0.298 |
| 43 | *Dianthus chinensis* L. | 4 | 81.79 | 0.251 | 0.0334 | 0.284 |
| 44 | *Zinnia elegans* Jacq. | 3 | 92.39 | 0.188 | 0.0907 | 0.279 |
| 45 | *Elymus dahuricus* Turcz. | 3 | 91.83 | 0.188 | 0.0891 | 0.277 |
| 46 | *Sambucus adnata Wall. ex* DC. | 4 | 88.72 | 0.251 | 0.0106 | 0.261 |
| 47 | *Mirabilis jalapa* L. | 4 | 93.23 | 0.251 | 0.0103 | 0.261 |
| 48 | *Paeonia lactiflora* Pall. | 3 | 89.32 | 0.188 | 0.0724 | 0.261 |
| 49 | *Canna indica* L. | 4 | 78.26 | 0.251 | 0.00795 | 0.259 |
| 50 | *Symphytum officinale* L. | 3 | 93.50 | 0.188 | 0.0398 | 0.228 |
| 51 | *Nymphaea tetragona* | 2 | 89.66 | 0.125 | 0.0875 | 0.213 |
| 52 | *Oxalis corymbosa* DC. | 3 | 91.43 | 0.188 | 0.0223 | 0.210 |
| 53 | *Lilium lancifolium* | 3 | 92.85 | 0.188 | 0.0223 | 0.210 |
| 54 | *Helichrysum bracteatum* Andr. | 3 | 85.07 | 0.188 | 0.0207 | 0.209 |
| 55 | *Fagopyrum gilesii* Hedb. | 3 | 88.15 | 0.188 | 0.0207 | 0.209 |
| 56 | *Pharbitis nil* Choisy | 3 | 90.81 | 0.188 | 0.0167 | 0.205 |
| 57 | *Gladiolus gandavensis* Vaniot Houtt | 3 | 87.63 | 0.188 | 0.0151 | 0.203 |
| 58 | *Heliopsis helianthoides* | 3 | 93.41 | 0.188 | 0.0127 | 0.201 |
| 59 | *Leucanthemum vulgare* Lam. | 3 | 90.33 | 0.188 | 0.0119 | 0.200 |
| 60 | *Cynoglossum zeylanicum* Thunb. | 3 | 89.79 | 0.188 | 0.0108 | 0.199 |
| 61 | *Phaseolus coccineus* Linn. | 3 | 90.18 | 0.188 | 0.00875 | 0.197 |
| 62 | *Dysosma tsayuensis* Ying | 2 | 90.67 | 0.125 | 0.0636 | 0.189 |
| 63 | *Prunella hispida* Benth. | 2 | 89.59 | 0.125 | 0.0557 | 0.181 |
| 64 | *Viola philippica* | 2 | 87.65 | 0.125 | 0.0398 | 0.165 |
| 65 | *Digitalis purpurea* L. | 2 | 88.75 | 0.125 | 0.0318 | 0.157 |
| 66 | *Equisetum diffusum* D. Don | 2 | 88.42 | 0.125 | 0.0318 | 0.157 |
| 67 | *Lilium wardii* | 2 | 91.26 | 0.125 | 0.0262 | 0.152 |
| 68 | *Sanvitalia procumbens* Lam. | 1 | 79.51 | 0.0627 | 0.0795 | 0.142 |
| 69 | *Azolla imbricata* Nakai | 2 | 84.37 | 0.125 | 0.00795 | 0.133 |
| 70 | *Impatiens holstii* Engler et Warb. | 2 | 88.57 | 0.125 | 0.00557 | 0.131 |
| 71 | *Tagetes erecta* L. | 2 | 91.73 | 0.125 | 0.00557 | 0.131 |
| 72 | *Anisodus tanguticus* Pascher | 2 | 92.21 | 0.125 | 0.00437 | 0.130 |
| 73 | *Tribulus terrester* L. | 2 | 86.34 | 0.125 | 0.00318 | 0.129 |
| 74 | *Helianthus tuberosus* L. | 2 | 89.88 | 0.125 | 0.00318 | 0.129 |
| 75 | *Elsholtzia ciliata* Hyland. | 2 | 86.35 | 0.125 | 0.00239 | 0.128 |
| 76 | Iris bulleyana | 1 | 87.37 | 0.0627 | 0.0477 | 0.110 |
| 77 | Others * | 43 | – | 1.818 | 0.404 | 2.222 |

Note: * means that there are a total of 42 other kinds of plants, with importance value less than 0.100.

**4.2 Plant composition** Survey shows that there are a total of 46 families, 95 genera, 119 species of ground cover plants in Tibetan herb garden, and there are 8 species of herbaceous climbing plants, accounting for only 6.72% of the surveyed plants. The families used most include *Asteraceae* (22), *Gramineae* (15), *Leguminosae* (8), *Labiatae* (7), *Iridaceae* (6) and *Liliaceae* (5), accounting for 18.49%, 12.61%, 6.72%, 5.88%, 5.04% and 4.20% of the surveyed plants, respectively. In terms of the plant composition, there are 64 kinds of native plants and 55 kinds of introduced plants, accounting for 53.78% and 46.22% of the surveyed plants, respectively. From the point of view of plant life cycle, there are 36 kinds of annual plants, 7 kinds of biennial plants and 76 kinds of perennial plants, accounting for 30.25%, 5.88% and 63.87% of the surveyed plants. It is dominated by the perennial herb garden ground cover plants.

**4.3 Characteristics of species abundance** Survey results show that the average species abundance of ground cover plants in Tibetan herb garden in each plot is 2.9, and the highest species abundance is 18. From Table 3, it can be found that Tibetan garden plant diversity is not wide and greening level is not high, with great differences. It is highest in Nyingchi and lowest in Nagqu. The greening pattern is relatively complex in the key towns of Nyingchi, Lhasa and Shannan; the greening structure is very simple in other places.

**Table 3 Species abundance statistics about the ground cover plants in Tibetan herb garden**

| No. | Regions | Species abundance index | The average number of species in the plot |
|---|---|---|---|
| 1 | Nyingchi | 101 | 4.56 |
| 2 | Lhasa | 48 | 3.39 |
| 3 | Shannan | 27 | 2.91 |
| 4 | Changdu | 26 | 2.93 |
| 5 | Xigaze | 20 | 2.68 |
| 6 | Ali | 13 | 1.95 |
| 7 | Nagqu | 12 | 1.88 |

**4.4 Species diversity index** By comparing the diversity index, it is found that in terms of Simpon index, the difference is significant, it is highest in Nyingchi and lowest in Nagqu; in terms of Shannon-wiener index and Pielou index, the difference is not significant. It indicates that there are significant differences in the diversity of Tibetan herb garden ground cover plant community, and the convergence is weak for all regions; there are no significant differences in homogeneity and dominance, and the convergence is strong for all regions. *Poa pratensis* L., *Festuca arundinace*, *Trifolium* L. and *Cosmos bipinnata* Cav. are heavily used as ground cover plants in Tibetan herb garden, so the difference in various values is small. It also shows that the greening landscape uniqueness is not obvious for the ground cover plants in Tibetan herb garden.

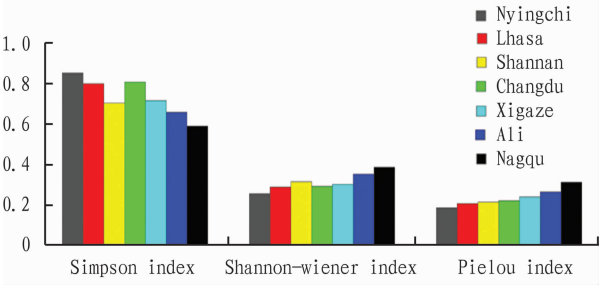


**Fig. 1 Species diversity index comparison**

**4.5 Greening mode** As for the green plants in Tibet, the upper layer trees mainly consist of white willow, cedar, *Populus beijingensis* W. Y. Hsu and elm, and white willow and cedar are dominant species. The middle layer plants consist of *Prunus ceraifera cv. Pissardii*, *Sabina chinensis* (L.) *Ant. cv. Kaizuca*, *Rosa chinensis Jacq.*, *Buxus megistophylla Levl.*, *Ligustrum* × *vicaryi Hort*, *Photiniaxfraseri*, *Berberis thunbergii* var. *atropurpurea* Chenault, *Platycladus orientalis* 'sieboldii', and *cv. Aurea Nana*. The lower layer plants are mainly composed of turf grass and a small number of ground cover plants such as *Trifolium* L., *Cosmos bipinnata* Cav., *Althaea rosea* (Linn.) Cavan., *Calendula officinalis* L., *Medicago sativa* L., *Dohlia Pinnata*, *Dendranthema morifolium* (*Ramat.*) *Tzvel.*, *Matthiola incana*, *Tropaeolum majus.*, and *Taraxacum sherriffii*[11]. The survey finds that in the wild, the gardens highly popular throughout Tibet often spontaneously form a large area of natural flower border, creating spectacular, stunning visual effects[13]. Various regions of Tibet place insufficient emphasis on non-lawn ground cover plants, and the large-scale ground cover plant landscape is mostly natural lawn landscape decorated with flowers rather than artificially created landscape[12]. It is mainly based on *Taraxacum sherriffii*, *Potentilla chrysantha*, *Sophora moorcroftiana*, and *Equisetum diffusum* D. Don.

**4.6 Lawn maintenance level** Due to Tibetan unique and harsh plateau natural environment, there are serious natural disasters in the landscaping area, with dry and windy winters. Due to the special natural environment conditions and constraints of concepts, funds and other factors, the maintenance level is low in Tibetan garden. Survey results show that the green space rate of non-artificial lawn in Tibet reaches as high as 38.51%, especially for Ali, Nagqu and Xigaze. The lawn with sparse grass is very common, and most of the artificial lawns are at maintenance level-4, dependent on the weather conditions (Table 4).

**Table 4 The lawn maintenance level in Tibet**

| Maintenance level | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Maintenance rate//% | 0.00 | 0.56 | 20.93 | 78.51 |

## 5 Conclusions and discussions

**5.1 Conclusions** This paper conducts a comprehensive survey of the ground cover plant in Tibetan herb garden for the first time using "five-point sampling method". Survey results show that: (i) A total of 46 families, 95 genera, 119 species of ground cover plants in herb garden are applied in Tibet, and *Asteraceae*, *Gramineae*, *Leguminosae*, *Labiatae*, *Iridaceae* and *Liliaceae* are used most, with the species number of 22, 15, 8, 7, 6 and 5, respectively, accounting for 18.49%, 12.61%, 6.72%, 5.88%, 5.04% and 4.20% of the plants surveyed, respectively. (ii) In terms of importance value for the herbaceous layer, the top three plants are *Poa pratensis* L., *Festuca arundinace* and *Lolium multiflorum* L., with the importance value of 45.950, 34.610 and 29.880, respectively; in terms of importance value for the non-turf ground cover herb plants, the top three plants are *Trifolium* L., Cosmos *bipinnata* Cav. and *Althaea rosea* (Linn.) Cavan., with the importance value of 4.372, 3.437 and 2.062, respectively. (iii) The overall level of greening is low and uneven in the region, with large regional differences. In terms of ground cover plant abundance, Nyingchi > Lhasa > Shannan > Changdu > Xigaze > Ali > Nagqu.

**5.2 Discussions** The survey shows that the landscaping diversity is poor and the problem of single configuration is prominent for Tibetan herb ground cover plants. The key factor affecting plant growth in the region is water factor, and it is mainly the water lack before germinating period in winter and spring[14]. For the regions with serious shortage of water, we can consider increasing the extensively managed plants with strong adaptability, such as *Trifolium* L., *Taraxacum sherriffii*, and *Potentilla chrysantha*. For the artificial lawn sensitive to water, it is necessary to place particular emphasis on watering in maintenance. In terms of species abundance index (Table 3), Tibetan green species abundance varies widely, and the greening development is highly uneven; it is highest in Nyingchi but generally poor in other cities. In Bayi District of Nyingchi City, Chengguan District of Lhasa City and Zedang Town of Shannan City, the artificial herbaceous ground cover plants are relatively abundant after several years of transformation and development[11, 15]. Contrastingly, it is mainly based on wild ground cover plants in other places, and the artificial ground cover plants are sporadically used, with monotonous level and poor species abundance. In Nagqu, it is mainly dominated by the model of "natural lawn decorated with rare shrubs", and most of green space has no tree layer and the single configuration problem is very prominent[11, 16]. Tibetan terrain difference leads to great changes in regional precipitation, largely affecting the ground cover plant abundance in the herb garden[17]. Survey results show that a total of 119 kinds of herb garden ground cover plants are used in Tibet, most in Nyingchi (101) and least in Nagqu (12), and there are significant regional differences in herb garden ground cover plant application (Table 7). In terms of plant resources and development, Tibet has rich native plant gardens, and Motuo County has more than 3500 kinds of plant resources[18]. Many outstanding native garden plants have not been fully utilized, including many excellent native ground cover plants in herb garden. In the future, it is necessary to focus on the selective breeding, and promote the local characteristic lawns decorated with flowers and the natural flower border plants with low maintenance cost, such as mallow, *Taraxacum sherriffii*, *Potentilla chrysantha*, *Iris lactea* and *Calystegia hederacea Wall*. There is also a need to strengthen the study on application form and innovation of rural lawn decorated with flowers and flower border.

## References


[1] HU LZ, GUAN XJ, MENG KA, *et al*. Introduction, screening and application evaluation of herbaceous ground cover plant in Hunan[J]. Journal of Southern Agriculture, 2013, 44(12): 2053 – 2057. (in Chinese).

[2] MA J, HAN LB, JIANG T. Assessment of ecological benefit for the introduction of drought-resistance and wild herbaceous ground cover species in Beijing area[J]. Journal of Beijing Forestry University, 2006, 28(1):51 – 55. (in Chinese).

[3] Comprehensive Scientific Expedition of Qinghai-Tibet Plateau, Chinese Academy of Sciences. Tibet forest[M]. Beijing: Science Press, 1985. (in Chinese).

[4] DONG SP. Study on the composition feature of gardening plant communities in main urban areas of Chongqing City[D]. Chongqing: Southwest *University*, 2006:16 – 18. (in Chinese).

[5] ZHAO JJ, OUYANG ZY, ZHENG H, *et al*. Proposed procedure in designing and planning stratified random selection investigation of urban vegetation[J]. Chinese Journal of Ecology, 2009, 28(7):1430 – 1436. (in Chinese).

[6] LI DS, GUO WJ, JI ZQ, *et al*. The impact of sample area and sample amount on the results of community species diversity measure-A case study with the shrub community in the west region of Yanshan Mountain[J]. Acta Agriculturae Universitis Jiangxiensis, 2008, 30(6):1079 – 1084. (in Chinese).

[7] LI K, WANG J, SHI L, *et al*. Research on the status of southern canal waterfront greening and plant landscape in Shenyang [J]. Journal of Shenyang Jianzhu University: Social Science, 2013, 15(2):153 – 155. (in Chinese).

[8] DU LH. Studies on the investigation and application of green plants in Nanjing new rural[D]. Nanjing: Nanjing Forestry University, 2012(6): 45 – 50. (in Chinese).

[9] LI YQ. Plant landscape research in Lijiang temple landscape architecture [D]. Ya'an: Sichuan Agricultural University, 2009: 16 – 18. (in Chinese).

[10] TANG L. Study on the characteristics of garden plant community of the main temple garden in Chengdu[D]. Ya'an: Sichuan Agricultural University, 2009: 20 – 21. (in Chinese).

[11] LIU ZN, XU J, ZHANG HF, *et al*. Investigation and application of landscape plants in Tibet[J]. Acta Agriculturae Zhejiangensis, 2016, 28(6):1009 – 1017. (in Chinese).

[12] LIU ZN, PAN G, ZHANG HF, *et al*. Investigation and application of landscape plants in Linzhi City of Tibet[J]. Acta Agriculturae Zhejiangensis, 2016, 28(2):273 – 283. (in Chinese).

[13] LIU ZN, PAN G, ZHANG HF, *et al*. Greening patterns of Tibetan courtyards in Linzhi City[J]. Landscape Research, 2016, 8(2):16 – 20.

[14] LIU ZN, PAN G, ZHANG HF, *et al*. Investigation and application research of landscape plants in Tibet of Shigatse City[J]. Northern Horticulture, 2015(20):74 – 78. (in Chinese).


(To page 70)

-772.

[39] MANICKAVASAGAM M, GANAPATHI A, ANBAZHAGAN VR, *et al.* Agrobacterium-mediated genetic transformation and development of herbicide-resistant sugarcane (Saccharum species hybrids) using axillary buds [J]. Plant Cell Reports, 2004, 23(3): 134 - 143.

[40] HPTTA CT, LEMBKE CG, DOMINGUES DS, *et al.* The biotechnology roadmap for sugarcane improvement[J]. Tropical Plant Biology, 2010, 3(2): 75 - 87.

[41] DEBIBAKAS S, ROCHER S, GARSMEUR O, *et al.* Prospecting sugarcane resistance to sugarcane yellow leaf virus by genome-wide association[J]. Theoretical & Applied Genetics, 2014, 127(8):1719 - 1732.

[42] ZHANG M, ZHUO X, WANG J, *et al.* Phosphomannose isomerase affects the key enzymes of glycolysis and sucrose metabolism in transgenic sugarcane overexpressing the manA gene. [J]. Molecular Breeding, 2015, 35(3):1 - 10.

[43] PRIJI PJ, HEMAPRABHA G. Sugarcane specific drought responsive candidate genes belonging to ABA dependent pathway identified from basic species clones of Saccharum sp. and Erianthus sp. [J]. Sugar Tech, 2014, 17(2):130 - 137.

[44] MCINTYRE CL, GOODE ML, CORDEIRO G, *et al.* Characterisation of alleles of the sucrose phosphate synthase gene family in sugarcane and their association with sugar-related traits [J]. Molecular Breeding, 2015, 35(3):1 - 14.

[45] CHEN ZL, GUI YY, QIN CX, *et al.* Isolation and expression analysis of sucrose synthase gene (ScSuSy4) from sugarcane[J]. Sugar Tech, 2015, 18(2): 134 - 140.

[46] CASU RE, JARMEY JM, BONNETT GD, *et al.* Identification of transcripts associated with cell wall metabolism and development in the stem of sugarcane by affymetrix gene chip sugarcane genome array expression profiling [J]. Funct Integr Genomics, 2007, 7(2): 153 - 167.

[47] CHEN MH, ZHANG BQ, SONG XP, *et al.* cDNA-SCoT analysis of differentially expressed genes in sugarcane induced by Leifsonia xyli subsp, xyli [J]. Acta Agronomica Sinica, 2013, 39(6): 1119 - 1126. (in Chinese).

[48] ZHANG JS, GUO CF, WANG BM, *et al.* Cloning and expression analysis of a water stress-induced ALDH gene from sugarcane [J]. Scientia Agricultura Sinica, 2009, 42(8): 2676 - 2685. (in Chinese).

[49] GILBERT RA, GLYNN NC, COMSTOCK C, *et al.* Agronomic performance and genetic characterization of sugarcane transformed for resistance to sugarcane yellow leaf virus[J]. Field Crops Research, 2009, 111(1 - 2): 39 - 46.

[50] ZHU YJ, MCCAFFERTY H, OSTERMAN G, *et al.* Genetic transformation with untranslatable coat protein gene of sugarcane yellow leaf virus reduces virus titers in sugarcane[J]. Transgenic Research, 2011, 20(3): 503 - 512.

[51] MCQUALTER RB, DALE JL, HARDING RM, *et al.* Production and evaluation of transgenic sugarcane containing a Fiji disease virus (FDV) genome segment S9-derived synthetic resistance gene[J]. Australian Journal of Agricultural Research, 2004, 55(2): 139 - 145.

[52] WEI YW. Studies on gene differential expressions regulated with ethephon and cloning of ethylene receptor gene Sc-ERS in sugarcane (Saccharum officinarum L.) [D]. Nanning: Guangxi University, 2007. (in Chinese).

[53] ALWALA S, KIMBENG CA. Molecular genetic linkage mapping in Saccharum: strategies, resources and achievements [M]. CRC Press, Science Publishers, 2010.

[54] WU R, MA CX, WU SS, *et al.* Linkage mapping of sex-specific differences[J]. Genetical Research, 2002, 79(1): 85 - 96.

[55] ANDRU S, PAN YB, THONGTHAWEE S, *et al.* Genetic analysis of the sugarcane (Saccharum spp.) cultivar 'LCP 85-384'. I. Linkage mapping using AFLP, SSR, and TRAP markers [J]. Theoretical and Applied Genetics, 2011, 123(1): 77 - 93.

[56] LIU XL, MAO J, LU X, *et al.* Construction of molecular genetic linkage map of sugarcane based on SSR and AFLP markers [J]. Acta Agronomica Sinica, 2010, 36(1): 177 - 183. (in Chinese).

[57] OLIVEIRA KM, PINTO LR, MARCONI TG, *et al.* Functional integrated genetic linkage map based on EST-markers for a sugarcane (Saccharum spp.) commercial cross[J]. Molecular Breeding, 2007, 20(3): 189 - 208.

[58] WANG J, ROE B, MACMIL S, *et al.* Microcollinearity between autopolyploid sugarcane and diploid sorghum genomes[J]. BMC Genomics, 2010, 11:261.

[59] MARGARIDO GRA, PASTINA MM, SOUZA AP, *et al.* Multi-trait multi-environment quantitative trait loci mapping for a sugarcane commercial cross provides insights on the inheritance of important traits[J]. Molecular Breeding, 2015, 35(8):1 - 15.

[60] BANERJEE N, SIRAREE A, YADAV S, *et al.* Marker-trait association study for sucrose and yield contributing traits in sugarcane ( Saccharum spp. hybrid) [J]. Euphytica, 2015, 205(1):185 - 201.

[61] SANTOS FRC, PINTO LR, CARLINI-GARCIA LA, *et al.* Marker-trait association and epistasis for brown rust resistance in sugarcane[J]. Euphytica, 2014, 203(3):533 - 547.

[62] GOUY M, ROUSSELLE Y, CHANE AT, *et al.* Genome wide association mapping of agro-morphological and disease resistance traits in sugarcane[J]. Euphytica, 2015, 202(2):269 - 284.

[63] PASTINA MM, PINTO LR, OLINEIRA KM, *et al.* Molecular mapping of complex traits [C]. Henry RJ, Kole C. Genetics, Genomics and Breeding of Sugarcane. CRC Press, Science Publishers,2010.

[64] WEI X, JACKSON P A, HERMANN S, *et al.* Simultaneously accounting for population structure, genotype by environment interaction, and spatial variation in marker - trait associations in sugarcane[J]. Genome, 2010, 53(11): 973 - 981.

(From page 65)

[15] LIU ZN, PAN G, ZHANG HF, *et al.* Investigation and application research on landscape plants in Lhasa[J]. Journal of Yunnan Agricultural University, 2016,31(4):670 - 680. (in Chinese).

[16] LIU ZN, PAN G, ZHANG HF, *et al.* Research on landscape plants in Shannan of Tibet[J]. Journal of Shandong Agricultural University(Natural Science Edition), 2016,47(7):82 - 89. (in Chinese).

[17] DA PQ, ZHANG KL, YE YH, *et al.* Restricting factors and countermeasures of reforestation project in Tibet Lhasa[J]. Tibetan Science & Technology,2010(5):13 - 16. (in Chinese).

[18] XING Z. A quantitative research onthe benefit of ecological environment of landscape plant in Tibet[M]. Beijing: Social Sciences Academic Press(China), 2014. (in Chinese).