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An Exploration of Candidate Korean Native Poaceae Plants for Breeding New Varieties as Garden Materials in the New Climate Regime Based on Existing Data

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Abstract: There is an increasing demand for low-maintenance public garden models, and environmental stress on plants due to climate change is growing. As a result, the demand for developing new plant varieties based on native species for use in gardens in response to climate change has increased significantly. Many plants in the Poaceae family are applied for various purposes, including food crops, fodder grasses, ornamental plants, and medicinal plants. Additionally, native plants provide economic and ecological benefits, making them advantageous for use in gardens. However, there are some difficulties in Poaceae breeding studies and the utilization of wild native plants for breeding. Model plants can be utilized in breeding studies of Poaceae plant species. In this study, to identify Korean native Poaceae species with the potential for use not only as garden materials but also as model plants for breeding research in response to climate change, candidate species were selected from the Korean Plant Names Index (KPNI). A total of three Korean native plants in the Poaceae family, including *Brachypodium sylvaticum*, *Setaria viridis*, and *Zoysia japonica*, were selected, and their properties and genome information were compared with the existing representative model plants, *Arabidopsis thaliana* and *Brachypodium distachyon*. The current research status of *B. sylvaticum*, *S. viridis*, and *Z. japonica* has been summarized, and the genome size and other characteristics of these model plants have been compared and discussed. As a result, both *A. thaliana* (2n = 2x = 10) and *B. distachyon* (2n = 2x = 10) are annual C_3 plants, but *B. sylvaticum* (2n = 2x = 18) is a perennial C_3 plant, and *S. viridis* (2n = 2x = 18) is an annual C_4 plant. Thus, *B. sylvaticum* and *S. viridis* can be utilized as model plants for perennial C_3 plants and annual C_4 plants, respectively. *Z. japonica* (2n = 4x = 40) is a perennial C_4 plant, but it can be unsuitable as a model plant because it is an allotetraploid. The application of these newly selected candidate plants in breeding research can build a foundation for breeding native Poaceae plants in Korea in the new climate regime.

Keywords: garden plants; model plants; molecular breeding; native plants; Poaceae; ornamental plants

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1. Introduction

The role of gardens in biodiversity conservation is expanding due to rapid urban growth, which has increased the need for low-maintenance public garden models [1,2]. Native plants can be used as garden materials for effective maintenance because they are good materials for gardens, restoration, and erosion control [3,4]. Recently, environmental stress on plants due to climate change is growing, and to cope with its brunt, plant breeding is valuable [5,6]. Therefore, the demand for developing new plant varieties based on native plants as garden materials against climate change has increased.

Many plants in the Poaceae family are used as food crops, fodder grasses, ornamental plants, and medicinal plants [7]. Souza et al. [8] described the capability of native Poaceae plants for usage as garden materials. Moreover, Dunster [9] argued that Poaceae should be used not only for ornamental purposes but also for a variety of functions in the age of climate change. However, some Poaceae species are polyploid or have large and complex genomes, which pose challenges for breeding studies [10]. To overcome this problem, model plants, which have many advantages, such as short life cycles and small genome sizes [11,12], can be utilized in breeding studies of Poaceae plant species.

Model plants are extensively researched in plant science or agriculture [11,13]. *Arabidopsis thaliana* has been widely applied as a model plant since the 1980s [14]. However, *Arabidopsis* is a dicotyledon in the Brassicaceae family, which is not advisable in some areas as a model plant of principal plants in the Poaceae family [15,16]. *Brachypodium distachyon*, which is distributed in the Mediterranean region, has been broadly investigated since the late 2000s by researchers and breeders on cereal crops, notably wheat and barley, which are valuable crops in the Triticeae tribe [17]. However, *B. distachyon* is not native to Korea, so it is not suitable for use as a garden material in Korea.

B. sylvaticum and *Setaria viridis* have been recently proposed for use as model plants in the Poaceae family [18]. *B. sylvaticum* can be utilized as a model plant for perennial grasses [19]. *S. viridis* has the potential to be applied as a model plant for C_4 photosynthesis exploration [20]. Both *B. sylvaticum* and *S. viridis* are native to Korea, so they are suitable for use as not only model plants but also garden materials in Korea.

Zoysia japonica, which is a perennial C_4 grass, is the most popular warm-season turfgrass in Korea [21,22]. The reference genome of *Z. japonica* and *Z. matrella* was assembled and available [23]. Also, transgenic *Z. japonica* accessions were obtained using the genetic transformation method [24]. Therefore, *Z. japonica* has not yet been referred to as a model plant, but it seems that it can be used as a model plant for both perennial C_4 plants and garden materials.

In this study, to identify Korean native Poaceae species with the potential to be used not only as garden materials but also as model plants for breeding research on abiotic stress tolerance in response to climate change, candidate species were selected from the Korean Plant Names Index (KPNI) based solely on previous research. The current research status of *B. sylvaticum*, *S. viridis*, and *Z. japonica*, which were finally selected from the KPNI, has been summarized, and their genome size, life cycle, and other characteristics have been compared with those of *A. thaliana* and *B. distachyon*, existing representative model plants, to evaluate their applicability. The main goals of this study are to establish criteria for selecting suitable candidate species for full-scale breeding research without incurring costs from expensive experiments and to review their applicability.

2. Materials and Methods

The list of Poaceae plant species was downloaded from the KPNI (http://www.nature.go.kr/kpni/, accessed on 11 July 2024). The scientific names of all plants were modified to remove information about authority, subspecies, or variety, leaving only the genus and species names. Since reference genomes are usually provided on a species basis, in the 'Classification' column, only 'Species' was selected, whereas 'Variety', 'Subspecies', 'Horticultural cultivar', and 'Cultivar' were deselected to filter the list (Supplementary Table S1). Furthermore, plant species with assembled reference genomes were investigated from the Published Plant Genomes database (https://www.plabipd.de/, accessed on 11 July 2024). A list of Poaceae plant species with assembled reference genomes was created based on the flowering plant cladogram, and their genome sizes were examined (Supplementary Table S2). Poaceae plant species with available reference genomes were selected from the KPNI list, and their characteristics, including life cycle and photosynthetic type, were investigated (Table 1). Since securing, cultivating directly, and evaluating all of the selected species take time and labor and is expensive, the analysis was conducted preferentially based on existing data. The life cycles of the selected plant species were investigated by the Korean Biodiversity Information System (http://www.nature.go.kr/, accessed on 12 July 2024) and the USDA PLANTS Database (https://plants.usda.gov/, accessed on 12 July 2024), and they were classified as annual or perennial. The photosynthetic types of the selected plants were investigated from previous studies, and they were classified as C_3 or C_4.

Table 1. Characteristics of 38 plant species in the Poaceae family selected from the KPNI.

Plant Category	Subfamily	Scientific Name	Genome Size (Mbps)	Life Cycle [z]	Photosynthetic Type
Native	Arundinoideae	*Phragmites australis*	1200	P	C_3 [25]
Native	Chloridoideae	*Leptochloa chinensis*	460	A	C_4 [26]
Native	Chloridoideae	*Eleusine indica*	590	A	C_4 [27]
Native	Chloridoideae	*Cynodon dactylon*	1020	P	C_4 [28]
Native	Chloridoideae	*Zoysia japonica*	390	P	C_4 [28]
Native	Oryzoideae	*Zizania latifolia*	1800	P	C_3 [26]
Native	Panicoideae	*Setaria viridis*	400	A	C_4 [29]
Native	Panicoideae	*Echinochloa oryzoides*	1000	A	C_4 [30]
Native	Panicoideae	*Microstegium vimineum*	1300	A	C_4 [31]
Native	Panicoideae	*Echinochloa crus-galli*	1400	A	C_4 [30]
Native	Panicoideae	*Themeda triandra*	840	P	C_4 [32]
Native	Panicoideae	*Miscanthus sinensis*	2500	P	C_4 [26]
Native	Pooideae	*Poa annua*	1800	A	C_3 [29]
Native	Pooideae	*Brachypodium sylvaticum*	360	P	C_3 [33]
Cultivated	Bambusoideae	*Phyllostachys edulis*	2080	P	C_3 [34]
Cultivated	Chloridoideae	*Zoysia matrella*	380	P	C_4 [35]
Cultivated	Chloridoideae	*Zoysia pacifica*	370	P	C_4 [35]
Cultivated	Oryzoideae	*Oryza sativa*	430	A	C_3 [29]
Cultivated	Panicoideae	*Panicum miliaceum*	920	A	C_4 [29]
Cultivated	Panicoideae	*Sorghum bicolor*	820	A	C_4 [29]
Cultivated	Panicoideae	*Coix lacryma-jobi*	1560	A	C_4 [29]
Cultivated	Panicoideae	*Zea mays*	2300	A	C_4 [29]
Cultivated	Panicoideae	*Setaria italica*	490	A	C_4 [29]
Cultivated	Pooideae	*Avena sativa*	4000	A	C_3 [29]
Cultivated	Pooideae	*Triticum aestivum*	17,000	A	C_3 [29]
Cultivated	Pooideae	*Hordeum vulgare*	5100	A	C_3 [29]
Exotic	Chloridoideae	*Eragrostis curvula*	660	P	C_4 [36]
Exotic	Panicoideae	*Saccharum spontaneum*	3360	P	C_4 [29]
Exotic	Panicoideae	*Paspalum notatum*	550	P	C_4 [29]
Exotic	Panicoideae	*Eremochloa ophiuroides*	800	P	C_4 [29]
Exotic	Panicoideae	*Panicum virgatum*	1200	P	C_4 [29]
Exotic	Pooideae	*Lolium rigidum*	2400	A	C_3 [29]
Exotic	Pooideae	*Poa pratensis*	3500	P	C_3 [29]
Exotic	Pooideae	*Alopecurus myosuroides*	3500	A	C_3 [37]
Exotic	Pooideae	*Lolium multiflorum*	600	A	C_3 [29]
Exotic	Pooideae	*Poa trivialis*	1350	P	C_3 [29]
Exotic	Pooideae	*Bromus tectorum*	2500	A	C_3 [29]
Exotic	Pooideae	*Lolium perenne*	2000	P	C_3 [29]

[z] P: perennial; A: annual.

Small genome size is one of the criteria for model plants [11]. The genome sizes of *Brachypodium distachyon*, the model plant for monocots but not native in Korea, and rice (*Oryza sativa*), which is the representatively cultivated crop but not native in Korea, are 270 Mbps and 430 Mbps, respectively. Rice is one of the major food crops in the world, and many studies have already been conducted. Some researchers have suggested the use of rice as a model plant for monocots due to its relatively small genome size. Thus, if the genome size of a candidate species is larger than rice, the species is not worth being used as a model plant. To add to this point, Korean native plant species with genome sizes smaller than that of rice were selected as candidate model plants. The current research states of the candidate model species were investigated. The candidate model plants were compared with the representative model plants, *Arabidopsis thaliana* and *Brachypodium distachyon*, and the properties of these plants were compared and analyzed (Table 2). Also, based on Phytozome 13 (https://phytozome-next.jgi.doe.gov/, accessed on 18 July 2024), the genomes of the 2 existing representative model plants and the 2 newly suggested model plants were summarized (Table 3). For each plant species, two versions of genomes were selected and compared. Because it had no genome information in Phytozome 13, it was hard to analyze *Zoysia japonica* directly with the other 4 plants. Therefore, based on other studies [23,38], the genome of *Zoysia japonica* was analyzed separately from those of other species in the *Zoysia* genus, such as *Z. matrella* and *Z. pacifica*, which are cultivated plants in Korea (Table 4).

Table 2. Basic information about the 2 representative model plants and the 3 candidate model plants.

	Arabidopsis thaliana	*Brachypodium distachyon*	*Brachypodium sylvaticum*	*Setaria viridis*	*Zoysia japonica*
Common name	mouseear cress	purple false brome	slender false brome	green bristlegrass	Korean lawngrass
Cotyledon	Eudicots	Monocots	Monocots	Monocots	Monocots
Order	Brassicales	Poales	Poales	Poales	Poales
Family	Brassicaceae	Poaceae	Poaceae	Poaceae	Poaceae
Tribe	Camelineae	Brachypodieae	Brachypodieae	Paniceae	Zoysieae
Genus	*Arabidopsis*	*Brachypodium*	*Brachypodium*	*Setaria*	*Zoysia*
Life cycle	Annual	Annual	Perennial	Annual	Perennial
Photosynthetic type	C_3	C_3	C_3	C_4	C_4
Chromosome number	2n = 2x = 10	2n = 2x = 10	2n = 2x = 18	2n = 2x = 18	2n = 4x = 40
Native in Korea	Y	N	Y	Y	Y

Table 3. Comparison of the reference genome data of the 4 model plants from Phytozome 13.

	Arabidopsis thaliana		*Brachypodium distachyon*		*Brachypodium sylvaticum*		*Setaria viridis*	
Genome version	TAIR10	Araport11	v2.1	v3.2	v1.1	v2.1	v2.1	v4.1
Source	TAIR	TAIR	JGI	JGI	JGI	JGI	JGI	JGI
Accession	'Col-0'	'Col-0'	'Bd21'	'Bd21'	'Ain-1'	'Ain-1'	'A10.1'	'A10'
Assembled genome size	119,667,750	119,667,750	271,997,306	271,163,419	358,283,154	360,731,464	395,731,502	397,277,387
No. of contigs	169	169	485	34	1117	14	75	39
Protein-coding transcripts	35,386	48,456	42,868	56,847	50,263	54,423	52,459	50,526
Protein-coding genes	27,416	27,655	31,694	32,439	36,927	31,643	38,334	29,807
Reference publication	Lamesch et al. [39]	Cheng et al. [40]			Lei et al. [41]		Mamidi et al. [42]	

Table 4. Comparison of the reference genome data of *Zoysia* species.

	Zoysia japonica		*Zoysia matrella*	*Zoysia pacifica*
Accession	'Yaji'	'Nagirizaki'	'Wakaba'	'Zanpa'
Estimated genome size	421 Mbps	390 Mbps	380 Mbps	370 Mbps
Genome version	unknown	ZJN_r1.1	ZMW_r1.0	ZPZ_r1.0
Source	unreleased	Zoysia Genome Database	Zoysia Genome Database	Zoysia Genome Database
Number of sequences	1350	11,786	13,609	11,428
Total length	373,429,196	334,384,427	563,438,595	397,009,957
Average length	276,614	28,371	41,402	34,740
Max. length	17,601,860	8,501,895	1,041,506	1,506,652
Min. length	unknown	500	500	500
N50 length	3,962,554	2,370,062	108,897	111,449
Number of predicted genes	50,140	59,271	95,079	65,252
Reference publication	Yang et al. [38]	Tanaka et al. [23]	Tanaka et al. [23]	Tanaka et al. [23]

3. Results

Of the 494 Poaceae plants listed in the KPNI, 352 were registered as species (Supplementary Table S1), and 38 were selected for analysis in this study (Table 1). The number of Korean native plants was 14, the number of cultivated plants was 12, and the number of exotic plants was 12, respectively. The number of plants with genome sizes less than 1 Gbps was 16. The number of annual plants was 20, whereas the number of perennial plants was 18. The number of the C_3 plants was 16, whereas the number of the C_4 plants was 22. Plants with genome sizes smaller than that of rice (*O. sativa*) were selected, resulting in five species chosen for analysis. Of them, three plants (*Brachypodium sylvaticum*, *Setaria viridis*, and *Zoysia japonica*) were native to Korea, whereas two plants (*Z. matrella* and *Z. pacifica*) were cultivated in Korea.

Thus, three Korean native plants were selected as the candidate model plants, and their properties and the two representative model plants (*Arabidopsis thaliana* and *Brachypodium distachyon*) were analyzed (Table 2). *A. thaliana* was determined to be eudicots in the Brassicaceae family, whereas the others were monocots in the Poaceae family. *A. thaliana*, *B. distachyon*, and *S. viridis* were annual, but *B. sylvaticum* and *Z. japonica* were perennial.

A. thaliana, *B. distachyon*, and *B. sylvaticum* were C_3 plants, whereas *S. viridis* and *Z. japonica* were C_4 plants. Both *A. thaliana* and *B. distachyon* were diploids with 10 chromosomes, but both *B. sylvaticum* and *S. viridis* were diploids with 18 chromosomes. Also, *Z. japonica* was a tetraploid with 40 chromosomes. Except for *B. distachyon*, the others were native plants in Korea.

The information on the genomes of the four plants (*A. thaliana*, *B. distachyon*, *B. sylvaticum*, and *S. viridis*) was obtained from Phytozome 13 and their reference publications (Table 3). Within the same species, assembled genome sizes sometimes varied depending on the genome version but were approximately the same. The genome size of *A. thaliana* was the smallest, followed by *B. distachyon*, *B. sylvaticum*, and *S. viridis*. Compared to *A. thaliana* and *S. viridis*, *B. distachyon* and *B. sylvaticum* showed relatively high differences in the number of contigs between the genome versions. As the genome versions were updated, the number of contigs decreased, indicating increased genome completeness through gap-filling. No constant trend was found in either the protein-coding transcripts or the protein-coding genes. As the genome versions were updated, the protein-coding transcripts of *A. thaliana*, *B. distachyon*, and *B. sylvaticum* increased, whereas those of *S. viridis* decreased. As the genome versions were updated, the protein-coding genes of *A. thaliana* and *B. distachyon* increased, whereas those of *B. sylvaticum* and *S. viridis* decreased.

The genome of *Z. japonica* was analyzed based on other studies (Table 4). There were large differences in the genomes of *Z. japonica* between Yang et al. [38] and Tanaka et al. [23]. Yang et al. [38] used the PacBio long-read sequencing, so the average length and maximum length they found were longer than those found by Tanaka et al. [23]. Also, Tanaka et al. [23] estimated the genome sizes of *Z. japonica*, *Z. matrella*, and *Z. pacifica* using flow cytometry as 390 Mbps, 380 Mbps, and 370 Mbps, respectively. The obtained genome sizes of *Z. matrella* and *Z. pacifica* were larger than the estimated genome sizes, whereas the obtained genome size of *Z. japonica* was smaller than the estimated genome size.

4. Discussion

Plants in the Poaceae family can be utilized in various ways [7]. However, most plant breeders focus on cereal crops such as rice, wheat, and maize, and only a few researchers have performed breeding programs for ornamental purposes [43]. Ornamental grasses in the Poaceae family are utilized in garden design and landscaping; these gardens are economically important in climate change acclimatization and extenuation [44,45]. Also, native plants have some economic and ecological benefits, and the utilization of native plants is advantageous in gardens [46,47]. Thus, although there is a need to study more diverse Korean native Poaceae species for garden plant breeding in response to increasingly severe and frequent abnormal climate damage by climate change, basic breeding studies on wild native plants in Korea are relatively scarce compared to cultivated crops.

Nowadays, breeders can utilize genomic resources such as reference genomes for molecular breeding for crop improvement [48]. Many species persist uncharted even though thousands of genomes have been explored [49]. Due to recent technological developments, various sequencing methods have been developed, and their cost is cheaper than before [50]. However, assembling the reference genome is still a costly, energy-demanding, and protracted task [51]. Furthermore, due to insufficient information, there are difficulties in utilizing wild plants for breeding [52]. Information obtained from model plants can be hypothesized for application to the target species of breeding, making it easier for researchers to conduct studies on those plant species [53]. Thus, building a foundation through research using model plants may play an important role in the breeding of wild native plants, which has not yet been explored. Additionally, if the model plant itself can be used as a garden material, it would be economically beneficial because it could be developed for a cultivar, not only for research purposes but also for practical use as a garden material.

Conducting experiments with actual plants requires significant time and money, and it is not feasible to include all plant species native to Korea. Therefore, it is crucial to select plant species for study using reasonable criteria before starting a full-scale experiment. In this study, to identify some Korean native Poaceae species with the potential to be used not only as garden materials but also as model plants for breeding research on abiotic stress tolerance in response to climate change, candidate species were explored from the KPNI based solely on previous research. A total of three native Korean Poaceae plants, including *Brachypodium sylvaticum*, *Setaria viridis*, and *Zoysia japonica*, were ultimately selected, and their characteristics and genome information were compared with those of representative model plants *Arabidopsis thaliana* and *Brachypodium distachyon*. Additionally, based on previous studies and existing data, the potential for using these plant species as garden materials in Korea will be discussed.

Brachypodium distachyon was first suggested as a model plant for cereals and forage grasses in 2001 [54]. *B. distachyon* is an annual C_3 grass and is primarily distributed in the Mediterranean region (Figure 1A). Meanwhile, in Japan, a country geographically close to Korea, *B. distachyon* was first discovered at the Shimizu Port in 1953, and it is classified as a naturalized plant [55,56]. In Korea, however, although *B. distachyon* has been used in studies since the late 2000s [57,58], the discovery of *B. distachyon* in the wilds of Korea has not yet been reported. According to the Köppen–Geiger climate classification system, *B. distachyon* mainly distributes in Bsh, Csa, Csb/Bsk, and Cfa/Cfb regions [59]. Also, most parts of Japan belong to the Cfa region [60], so *B. distachyon* can survive there. However, most of the Korean Peninsula is composed of the Dwa climate, and Cfa is mainly observed in some southern regions, including Wando and Jeju [61,62]. Actually, in some island regions of the southern part of the Korean Peninsula, mainly Jeju Island, there are some plant species that are not distributed in the Korean Peninsula but are instead distributed in China, Japan, and Taiwan [63]. Therefore, it is reasonable to judge that *B. distachyon* would be able to adapt naturally and survive only in some southern regions of Korea, and it is inevitable that it will require significant effort and high costs to artificially cultivate *B. distachyon* as a garden material in most regions of Korea. For this reason, even though *B. distachyon* is a model plant for Poaceae plants, it is inefficient to use it for breeding purposes as a garden material in Korea.

Unlike *B. distachyon*, *B. sylvaticum* is a perennial C_3 grass native to Korea (Figure 1B). Both *B. sylvaticum* and *B. distachyon* are plants in the *Brachypodium* genus of the Pooideae subfamily, so they are genetically close to each other [64]. Genetically close species can be utilized for breeding with hybridization and introgression [65]. The first version of the reference genome of *B. distachyon* was announced in 2010 [66]; by comparison, the reference genome of *B. sylvaticum* was recently reported [41]. Steinwand et al. [19] suggested *B. sylvaticum* for use as a model plant for perennial grasses. Also, according to Kim [67], *B. sylvaticum* was one of the potential candidates for ornamental grasses, and it was applied abroad but not in Korea. Therefore, *B. sylvaticum* can be utilized not only as a model plant for perennial C_3 grasses but also as a garden material in Korea.

In the *Brachypodium* genus of the Pooideae subfamily, there is no species that is native or cultivated in Korea apart from *B. sylvaticum*. In the Pooideae subfamily, there are many significant C_3 perennial grasses, such as bentgrasses (*Agrostis* spp.), bluegrasses (*Poa* spp.), fescues (*Festuca* spp.), and ryegrasses (*Lolium* spp.), applied as turf in temperate zones [68]. Except for annual cereal crops such as wheat, barley, and oat, and their relatives, only a few plants for a perennial turf in the Pooideae subfamily, such as *Poa pratensis* and *Lolium perenne*, have been studied for reference genome assembly [69,70]. Therefore, *B. sylvaticum* can be utilized as a model plant for perennial cool-season grasses whose reference genomes have not been reported, such as bentgrasses (*Agrostis* spp.) and fescues (*Festuca* spp.) in Korea.

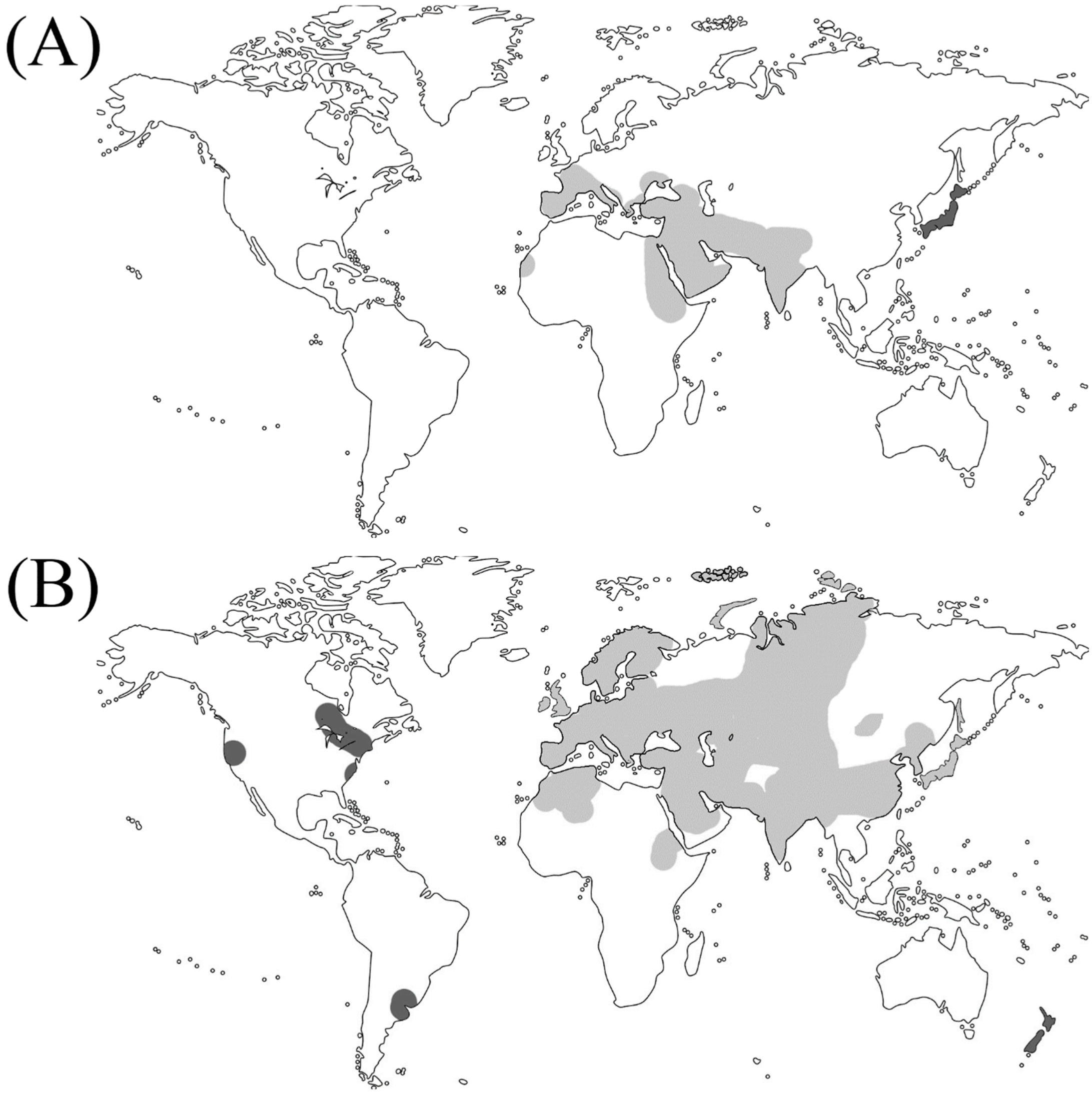

Figure 1. Geographic distributions of *B. distachyon* (**A**) and *B. sylvaticum* (**B**). Bright gray indicates native regions, and dark gray indicates introduced regions.

S. viridis is an annual C_4 grass in the Panicoideae subfamily, which includes many economically valuable C_4 species such as maize, sorghum, and sugarcane [71]. Brutnell et al. [20] suggested the use of *S. viridis* as a model plant for C_4 photosynthesis. The reference genomes of *S. viridis* were first reported in 2020 [42,72]. Therefore, compared to *B. distachyon*, *S. viridis* received attention relatively late as a model plant. However, *S. viridis* can be transformed using the floral-dip method, which has not yet been reported in *B. distachyon* [73]. As a result, *S. viridis* is used for genome editing research, such as CRISPR/Cas9 [74]. Additionally, various studies on C_4 photosynthesis using *S. viridis* as a model plant were conducted [75,76]. Therefore, *S. viridis* is highly valuable for breeding research within the Poaceae family alongside *B. distachyon*.

In the *Setaria* genus, some species were applied as garden materials. *S. italica*, which is cultivated for food or forage in Korea, was planted and analyzed for composition and utilization in garden settings [77]. Also, according to Frey and Moretti [78], four species in the *Setaria* genus (*S. italica*, *S. pumila*, *S. verticillata*, and *S. viridis*) were discovered in urban gardens. Additionally, in the Panicoideae subfamily, the *Paspalum* genus and the *Axonopus* genus have been applied for lawns [79]. Apart from *S. viridis*, the reference genomes of *S. italica* and *Paspalum notatum* have been reported [80,81], but those of *S. pumila*, *S. verticillata*, and carpet grasses (*Axonopus* spp.) have not yet been reported. Also, *S. viridis* has a smaller genome than *S. italica* [72,82]. Therefore, *S. viridis* can be utilized as a model plant for annual C_4 grass for garden materials.

Z. japonica is a widely used turfgrass that is distributed in East Asia, including in Korea, Japan, and China [83,84]. The genomes of *Z. japonica* were reported by Tanaka et al. [23] and Yang et al. [25]. However, there were large differences between the two genomes; therefore, further studies should be conducted to improve accuracy (Table 4). Also, considering the errors in *Z. japonica*, the estimated genome sizes of the other species, *Z. matrella* and *Z. pacifica*, could be uncertain as well. Therefore, genome assemblies of both *Z. matrella* and *Z. pacifica* using other accessions would be required to estimate more accurate genome sizes of both species. Additionally, utilizing *Z. matrella* and *Z. pacifica* as garden materials in Korea will inevitably require significant cost and effort, as these species are not native but cultivated in the country.

B. distachyon, *B. sylvaticum*, and *S. viridis* were reported as model plants for annual C_3 grasses, perennial C_3 grasses, and annual C_4 grasses, respectively, whereas a model plant for perennial C_4 grasses has not been reported. The *Zoysia* genus, which consists of 11 species, is a perennial C_4 grass in the Chloridoideae subfamily and is native to the western Pacific Rim and Indian Ocean [84,85]. *Z. japonica*, *Z. matrella*, and *Z. pacifica* have been utilized as turf and ornate grasses [83]. Also, their genome sizes were relatively small [23], so one species in the *Zoysia* genus, which are perennial C_4 grasses, can be utilized as a model plant for perennial C_4 grasses. However, compared to *B. sylvaticum* and *S. viridis*, plants in the *Zoysia* genus were less studied, probably because they are not native to Europe or America. Additionally, plants in the *Zoysia* genus were allotetraploids, but Flavell [86] presented diploid genetics as one of the characteristics of model plants. Therefore, *Zoysia* species are suitable as garden materials but can be unsuitable as model plants. For the appearance of a model plant for perennial C_4 grasses, the discovery of a diploid perennial C_4 species with a small genome size is necessary.

5. Conclusions

In summary, three candidate plants were selected as model plants for breeding garden materials in Korean native Poaceae plants. *Brachypodium sylvaticum* and *Setaria viridis* were used as model plants for perennial C_3 grasses and annual C_4 grasses, respectively; thus, they could also be utilized in breeding research for garden materials. *Zoysia japonica* cannot be a model plant for perennial C_4 grasses, but it has been studied and applied for various horticultural purposes. The application of these newly selected candidate plants in breeding research can build a foundation for the breeding of native Poaceae plants in Korea and contribute to the garden industry in Korea. Also, further research is required for the breeding and utilization of native plants in preparation for the new climate regime.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/horticulturae10111158/s1. Table S1: The list of 352 species registered as 'species' of the 494 Poaceae plants listed in the Korean Plant Names Index (KPNI); Table S2: The list of Poaceae plant species with assembled reference genomes based on the flowering plant cladogram from the Published Plant Genomes database.

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