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Morphological Variation of Bermudagrass along Longitudinal and Latitudinal Gradients under in-situ and ex-situ conditions

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Abstract

Bermudagrass [*Cynodon dactylon* (L.) Pers.], a polymorphic and cosmopolitan warm-season grass, was widely used for turf, forage and soil stabilization. Estimation of genetic variation based on the morphological characteristics have been developed in an attempt to eliminate the environmental effects. Our work focuses on comparing the value of morphological characterization of in situ and ex situ to find whether there is a strong environmental influence on the morphological characteristics of *C. dactylon* along longitudinal and latitudinal gradients. No significant differences were found in the variation of plant height, leaf width, internode length, and stolon diameter between the same populations in situ and ex situ. Both morphological characterization of *C. dactylon* in situ and ex situ are equally valuable for the estimation of the germplasm collection and evolutionary studies of the species.

Morphological variation under in-situ condition

C. dactylon are also highly diversified in ecology and morphology, with growing in tropic, subtropic, and temperate zones, and from Africa to South America, Africa, Europe, and South Asia (Harlan and De Wet, 1968; Taliaferro, 1995; Dong and Shen, 2003). Larger morphological sizes of *C. dactylon* appeared at the low- and high-latitude regions, while leaves of the erect shoot and the internode length enlarged significantly with the collection sites moving from east to west (Zhang *et al*., 2018; Wang *et al*., 2020). This supports the conjecture that at low- and high-latitude sites, leaf length, leaf width and circumference are being selected in the opposite direction when compared to the mid-latitude sites. High morphological variations were significantly correlated with climate factors and soil nutrients. Environmental effects on plant morphological characters were obvious in this study, reflecting plasticity for morphological appearance against longitude and latitude. Morphological size was influenced by longitude and latitude-related environmental factors, suggesting a different breeding goals and morphological adaptation. The morphological variations could lead to physiological changes and improved ecological tolerances. Some results of other studies which suggest evolutionary adaptation to an expanded range might require modifications in vegetative development (size, growth) (Geber and Eckhart, 2005).

Morphological variation under ex-situ condition

The environment along longitudinal and latitudinal gradients have possibly high effect on the morphological, so the pattern of morphological variation under homogeneous growing conditions ex situ was compared with those already reported in situ to validate this methodology. Morphological characteristics including plant height, leaf width, internode length, stolon length and stolon diameter of Bermudagrass were examined on the materials that were grown in the common garden. The pattern of variation revealed by variation coefficients and cluster analysis were similar both in ex situ conditions and in situ conditions, because in both studies the populations formed the same morphotypes. Inconsistencies were found between the two conditions, the internode length and stolon diameter of high- latitude populations tended to have greater size than those from the low- and mid-latitudes under ex situ conditions, while under in situ conditions, these two characters were lower at mid-latitude. Internode length and stolon diameter at different latitudes are influenced by latitude-related soil characters and climate factors for adaptive phenotypic plasticity. However, we think that this inconsistency has little relevance. The morphological characterization of fruit was used to estimate the evolution and diffusion (Harries, 1978). Morphological characterization in situ can be a useful methodology with low technological for genetic diversity studies, the design of strategies for the conservation of *C. dactylon*.

Relationship among the morphological characters and ploidy levels for bermudagrass breeding

Morphological traits varied with ploidy level across the 27 geographic regions along longitudinal and latitudinal gradients. Among ploidy levels, plant height and leaf width of triploids were smaller than those of the hexaploids, indicating that the Chinese wild *C. dactylon* contained much wider morphological diversity among different ploidy levels. Polyploids have been studied for their morphological, physiological and developmental differences from diploids to find the correlative evidence explaining observations that polyploids can adapt better to different environments. One sample of morphological differences between diploids and polyploids are the larger cell sizes in polyploids including those of the stomata (Speckman *et al*., 1965; Melaragno *et al*., 1993; Masterson, 1994; Hodgson *et al*., 2010). A hexaploid Bermudagrass such as *C.dactylon* cv. 'Tifton 10' tends to have thick stolons and coarse-textured long leaves (Wu *et al*., 2005, 2006). Morphological effects of polyploidization could include bigger flowers, delayed and prolonged flowering, an altered length/width ratio of leaves, a darker green coloration of the leaves, or thicker leaves and stems as in Buddleja (Rose *et al*., 2000), Salvia (Kobayashi *et al*., 2008). Inducing novel morphological characteristics by ploidy breeding is a powerful tool that could lead to commercial success in plants.

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