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# Contributions of different regulatory mechanisms to osmotic potential changes in three *Caragana* species on the Mongolian plateau

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## Introduction

The genus *Caragana* of legume family is endemic to the temperate grasslands of Eurasia (Cao *et al*., 1999). *Caragana* species are broadly distributed in the temperate Asia zone (E30°–140°, N28°–56°). *Caragana microphylla*, *Caragana davazamcii*, and *Caragana korshinskii* are typical representatives of the genus *Caragana* in central Asia. The three *Caragana* species exhibit a geographically substituted distribution from east (semi arid habitat) to west (arid habitat) on the Mongolian Plateau. Existing studies investigating the reasons for the interspecific geographical transition of the three *Caragana* species have primarily focused on RAPD analysis, photosynthetic capacity, and hydraulic architecture. In contrast, information on the adjustment mechanisms in $\Psi_\pi$ changes remains limited; particularly regarding the relative contributions of the main three regulatory mechanisms knows little.

## Materials and Methods

Based on the geographically distribution pattern of *Caragana* species on the Inner Mongolian Plateau (Li *et al*., 2007), three sites were selected as study areas (Table 1). The most easterly site was located at the Inner Mongolia Grassland Ecosystem Research Station (IMFERS). The central site was located at Huangfuchuan Station. The most westerly site was located at the Ordos Sandland Ecological Station (OSES). Habitat aridity increased along water gradient. The dominant *Caragana* species at each site was investigated, *i.e*., *C. microphylla*, *C. davazamcii*, and *C. korshinskii* at IMFERS, IMHS, and OSES, respectively.

**Table 1:** Characteristics of the three study sites

| Study site | Longitude (°E) | Latitude (°N) | Altitude (m) | Annual precipitation (mm) | Annual average temperature (°C) | Climate type | Soil type |
|---|---|---|---|---|---|---|---|
| MFERS | 116°42′ | 43°38′ | 1187 | 350 | 2 | Temperate semi-arid continental steppe climate | Chestnut soil |
| IMHS | 111°07′ | 39°45′ | 1100 | 369 | 6.2 | Typical semi-arid climate | Chestnut soil |
| OSES | 109°51′ | 39°02′ | 1300 | 330 | 7 | Semiarid steppe region | Sandy–chestnut soil |

On three sunny windless days in the mid-July in 2012, we randomly selected 15-year-old mature plants of *C. microphylla*, *C. davazamcii*, and *C. korshinskii* to measure $\Psi_w$ and $\Psi_\pi$ at fully expanded sun leaves from 1-year-old healthy branches of the selected plants. Five plants of each *Caragana* species were randomly selected, with three leaves from two branches of each plant being measured. Diurnal changes in $\Psi_w$ and $\Psi_\pi$ were measured using a Psypro Dew Point Microvoltmeter (Wescor Company, USA) once every 2 h from 06:00 to 20:00 each day. In addition, leaf relative water content (RWC), turgid weight (TW), and dry weight (DW) were determined using the same leaf tissue as that used for $\Psi_\pi$ measurement using the drying weighing method. Then, using the method described by Girma and Krieg (1992), we analyzed the relative contributions of different regulatory pathways.

## Results and Discussion

All three *Caragana* species exhibited similar diurnal variation in $\Psi_\pi$ (Fig. 1). Specifically, $\Psi_\pi$ drastically declined before noon, reaching the lowest point at 14:00, and then began to rise with increasing atmospheric humidity as light intensity and temperature decreased. However, *C. korshinskii* exhibited the greatest decreasing amplitude. Plants with lower $\Psi_\pi$

exhibit a stronger capacity to avoid dehydration and maintain turgor pressure. Therefore, *C. korshinskii* showed the strongest drought tolerance.

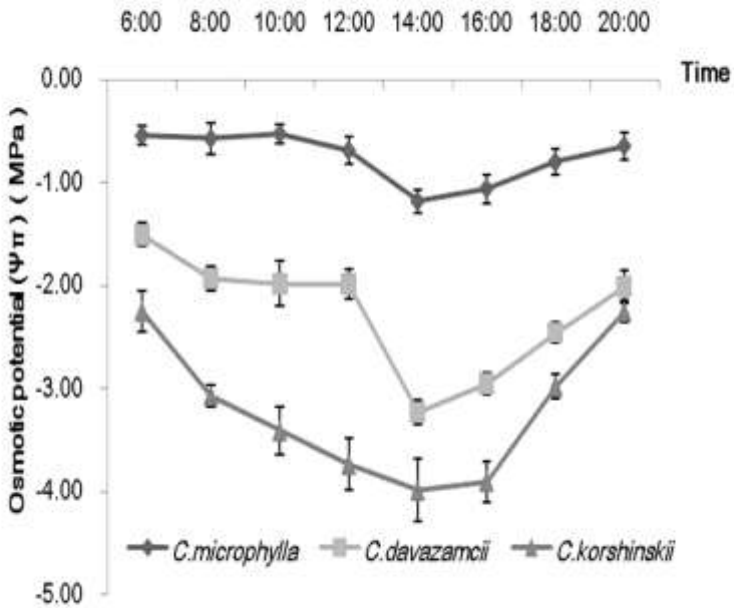


**Fig. 1.** Showed that the total amount of diurnal variation in $\Psi_\pi$ ($\Delta\Psi_\pi$) of *C. microphylla*, *C. davazamcii*, and *C. korshinskii* was -0.34 MPa, -0.59 MPa, and -1.0 MPa, respectively. Dehydration and net solute accumulation represented the main regulatory mechanisms for $\Psi_\pi$ changes in all three *Caragana* species, whereas non-permeable osmotic volume change had a minimal effect (Table 2 and Fig. 2). Although the relative contribution of cell size reduction was small, its importance increased with decreasing longitude (i.e., as aridity intensified) from *C. microphylla* to *C. davazamcii* and *C. korshinskii*.

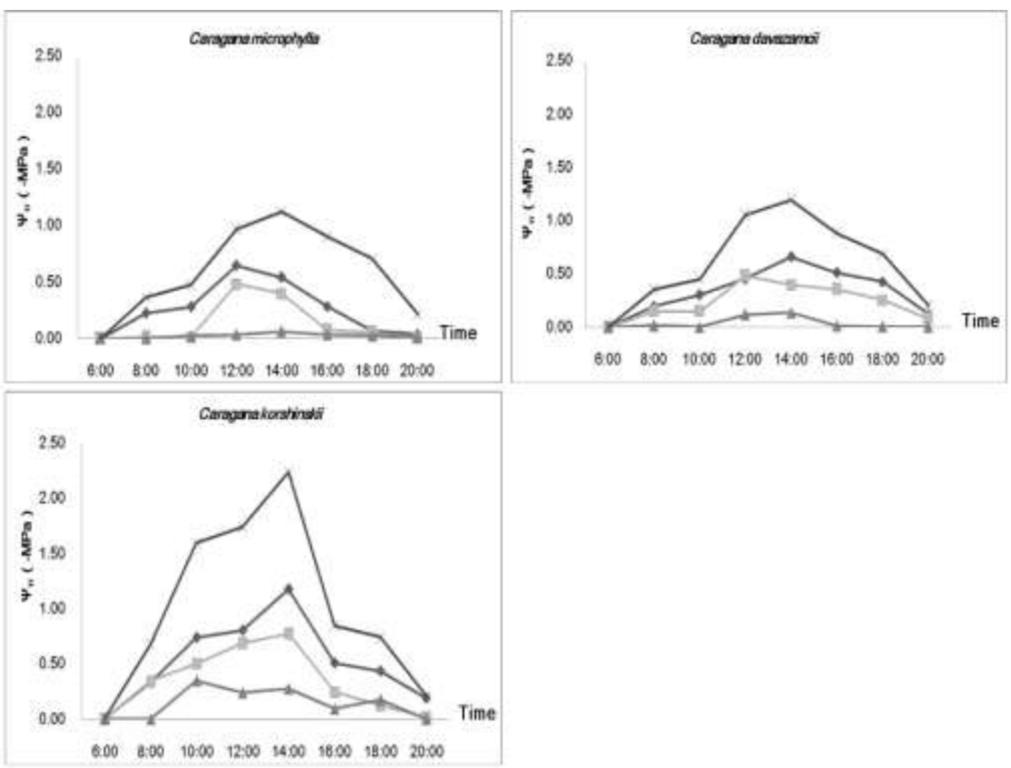


**Fig. 2.** Diurnal variations in $\Delta\Psi_\pi$, $-\Psi_\pi^{d}$, $-\Psi_\pi^{net}$, and $-\Psi_\pi^{td}$ of *C. microphylla*, *C. davazamcii*, and *C. korshinskii* (each data point represents pooled data of 3-d measurements for every *Caragana* species)

**Table 2:** Relative contributions of three pathways to diurnal $\Psi_\pi$ changes

| Pathways | Relative contributions (%) | | |
|---|---|---|---|
| | ***C. microphylla*** | ***C. davazamcii*** | ***C. korshinskii*** |
| Dehydration | 76 | 56 | 52 |
| Net solute accumulation | 38 | 39 | 34 |
| Non-permeable volume change | 4.5 | 10 | 14 |

The elastic regulation capability of the plant cell is proportional to its drought resistance. A higher ε value indicates a more rigid and less elastic cell wall. The ε values of *C. microphylla*, *C. davazamcii*, and *C. korshinskii* were 24.5 MPa, 19.2 MPa, and 14.9 MPa, respectively, and their interspecific differences were significant. Cell wall elasticity was ordered: *C. korshinskii* > *C. davazamcii* > *C. microphylla,* indicating that the regulation capacity of cell elasticity gradually increased as habitat aridity increased. Shi *et al*., (2003) thought that the plants' ε increased once drought started. However, our results showed the ε values of the three *Caragana* species didn't change with decreasing $\Psi_{w,}$ and their entire relation coefficient was lower than 0.1, indicating that the cell wall elasticity of all three *Caragana* species was relatively stable under natural conditions, and the amount of cell wall elasticity may be an inherent property.

## Conclusion

The three *Caragana* species growing in arid or semi arid habitats displayed distinct water regulation mechanisms. Overall, dehydration and net solute accumulation were vital mechanisms involved in diurnal $\Psi_\pi$ adjustment in all three *Caragana* species. However, cell volume changes caused by the accumulation of non-soluble polymers increasingly contributed to $\Psi_\pi$ changes from *C. mircophylla* to *C. davazamcii* and *C. korshinskii*. In addition, higher cell elasticity in *C. korshinskii* also helped to maintain lower $\Psi_w$ and $\Psi_\pi$. Therefore, the capacity of drought resistance was ordered: *C. mircophylla* < *C. davazamcii* < *C. korshinskii*. Also, these results demonstrate that there is a stable cell water physiological basis for the geographically substituted distribution of the three *Caragana* species on the Mongolian Plateau.

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