Effect of Glycinebetaine Seed Priming on the Tolerance to Abiotic Stresses in Turfgrass

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Objective:

1. *Determine the potential of improving the tolerance to water−related stresses (i.e. drought, salinity, and extreme temperatures) during germination and seedling growth through glycinebetaine seed priming;*
2. *Determine the role of glycinebetaine in the enhancement of water−related stresses.*

Plants are the most venerable to stresses during germination and seedling growth. Seed priming is an effective technique for rapid and uniform germination. Some research showed enhanced germination in vegetable and crop seeds primed with glycinebetaine (GB), an osmoprotectants, under stress. Other studies, however, found GB priming did not improve crop production. Information on turfgrass responses to GB priming is lacking. Furthermore, the physiological mechanisms of GB priming have not been well studied.

In this project, plant materials included: creeping bentgrass (CB), Kentucky bluegrass (KB), tall fescue (TF), perennial ryegrass (PR), zoysiagrass (ZOY), and bermudagrass (BER). Turfgrass seeds were either unprimed or primed with water or GB (5, 10, or 50 mM), then exposed to extreme temperatures [Topt (optimal germination temperature), Topt±5 °C, and Topt±10 °C] (Experiment 1), drought (0.0, −0.4, −0.8, and −1.2 MPa) (Experiment 2), or salinity (0, 5, 10, 15, and 20 dS m−1) (Experiment 3) under the controlled environment.

In Experiment 1, relative final germination rate (RFGR) and daily germination rate (RDGR) were affected by a temperature x species interaction.

Table 1. Relative final germination rate (RFGR) as affected by temperature and turfgrass species. Turfgrass seeds were either unprimed or primed with water or glycinebetaine (5, 10, or 50 mM). Data were pooled across the priming treatments and presented as % of the control (unprimed seeds germinated under optimal temperature) within each species. Optimal germination temperature (Topt) was 25/15 °C (day/night) for creeping bentgrass (CB), Kentucky bluegrass (KB), tall fescue (TF), and perennial ryegrass (PR) and 30/20 °C for bermudagrass (BER) and zoysiagrass (ZOY). Data were organized by the RFGR values under Topt.

Species	Temperature (°C)				
	T_{opt} - 10 °C	T_{opt} - 5 °C	T_{opt}	T_{opt} + 5 °C	T_{opt} + 10 °C
ZOY	32.2 C d	60.9 C c	110.3 A b	119.9 B a	118.5 A ab
KB	13.0 E d	29.8 D c	105.0 AB b	142.2 A a	12.9 F d
CB	97.2 A[Y] c[Z]	101.4 A ab	102.7 BC a	102.6 C a	97.5 B bc
BER	20.8 D c	68.6 B b	102.5 BC a	97.3 C a	71.9 D b
PR	94.4 A a	97.0 A a	96.8 CD a	96.3 C a	88.7 C a
TF	85.6 B b	98.4 A a	92.9 D a	97.9 C a	62.9 E c

[Y] Uppercase letters indicated differences of turfgrass species under each drought level at $P \le 0.05$.
[Z] Lowercase letters indicated differences of drought levels within turfgrass species at $P \le 0.05$.

Temperature did not affect RFGR in PR (Table 1). In other grasses, the highest and lowest RFGR were observed at Topt or Topt+5 °C and Topt−10 °C respectively, except TF. Limited variations existed in RFGR in turfgrass species at Topt, but more were observed at other temperatures. For RDGR, the highest values were observed at Topt+5 °C, followed by Topt or Topt+10 ° C, and the lowest was at Topt−10 °C in all species, except TF (Table 2). Cool-season grasses (excluding KB) had higher RDGR than warm-season grasses at low temperatures (5 or 10 °C below Topt), while ZOY performed the best at high temperatures (5 or 10 °C above Topt). Glycinebetaine only affected RDGR. Seeds primed with water had the highest RDGR (87.4% of the control), followed by those primed with GB at 10 mM (86.0% of the control), and no differences were found in other priming treatments (average = 82.8% of the control) (data not shown).

In Experiment 2, a drought x species interaction was observed in RFGR and RDGR. Relative final germination rate and RDGR decreased with an increase of drought severity (Tables 3 and 4). Grasses performed similarly under non-stress condition. Perennial ryegrass had higher RFGR and RDGR than other grasses at −1.2 MPa. Similar, RFGR and RDGR were the highest in PR at −0.4 and −0.8 MPa. Creeping bentgrass performed better than other grasses at −0.4 MPa, while ZOY outperformed other grasses at −0.8 MPa. Glycinebetaine had no effect on germination under drought.

Experiment 3 is currently ongoing. Three other experiments will be conducted to determine the physiological mechanisms of GB priming under temperature, drought, and saline conditions in turfgrass.

Summary Points

- Turfgrass responded differently to extreme temperatures and drought stress.
- Effect of GB seed priming may differ in stresses. Mechanisms of GB priming are to be determined.
- Higher reduction was observed in RDGR than RFDR as stresses progressed, indicating that RDGR was a more sensitive indicator of stress tolerance.

Table 2. Relative daily germination rate (RDGR) as affected by temperature and turfgrass species. Turfgrass seeds were either unprimed or primed with water or glycinebetaine (5, 10, or 50 mM). Data were pooled across the priming treatments and presented as % of the control (unprimed seeds germinated under optimal temperature) within each species. Optimal germination temperature was 25/15 °C (day/night) for creeping bentgrass (CB), Kentucky bluegrass (KB), tall fescue (TF), and perennial ryegrass (PR) and 30/20 °C for bermudagrass (BER) and zoysiagrass (ZOY). Data were organized by the RDGR values under Topt.

Species	Temperature (°C)				
	T_{opt} - 10 °C	T_{opt} - 5 °C	T_{opt}	T_{opt} + 5 °C	T_{opt} + 10 °C
ZOY	17.6 D[Y] e[Z]	33.6 DE d	116.7 A c	172.2 A a	150.8 A b
CB	65.1 A d	96.4 A c	110.3 AB b	123.4 C a	91.0 B c
KB	11.2 E c	30.1 E c	109.5 AB b	186.3 A a	13.2 D c
PR	59.4 B d	87.3 B c	106.8 B b	117.9 C a	83.6 B c
BER	11.7 E d	39.3 D c	106.0 B b	149.1 B a	88.6 B b
TF	51.4 Cd	76.5 C c	86.7 C b	101.8 D a	36.3 C e

[Y] Uppercase letters indicated differences of turfgrass species under each drought level at P ≤ 0.05.
[Z] Lowercase letters indicated differences of drought levels within turfgrass species at P ≤ 0.05.

Table 3. Relative final germination rate (RFGR) as affected by drought and turfgrass species. Turfgrass seeds were either unprimed or primed with water or glycinebetaine (5, 10, or 50 mM). Data were pooled across the priming treatments and presented as % of the control (unprimed seeds germinated under 0.0 MPa) within each species. Data were organized by the RFGR values at –0.4 MPa.

Species	Drought (MPa)			
	0.0	-0.4	-0.8	-1.2
Perennial ryegrass	109.8 A[Y] a[Z]	91.9 A b	65.2 A c	4.6 A d
Creeping bentgrass	96.3 A a	59.9 B b	12.2 CD c	0.9 B d
Tall fescue	104.4 A a	43.5 BC b	12.7 C c	1.2 B d
Zoysiagrass	103.3 A a	40.0 C b	23.8 B c	3.7 B d
Bermudagrass	94.4 A a	27.5 CD b	2.9 D bc	0.0 B c
Kentucky bluegrass	103.2 A a	15.5 D b	4.7 D bc	0.0 B c

[Y] Uppercase letters indicated differences of turfgrass species under each drought level at $P \leq 0.05$.
[Z] Lowercase letters indicated differences of drought levels within turfgrass species at $P \leq 0.05$.

Table 4. Relative final germination rate (RDGR) as affected by drought and turfgrass species. Turfgrass seeds were either unprimed or primed with water or glycinebetaine (5, 10, or 50 mM). Data were pooled across the priming treatments and presented as % of the control (unprimed seeds germinated under 0.0 MPa) within each species. Data were organized by the RDGR values at –0.4 MPa.

Species	Drought (MPa)			
	0.0	-0.4	-0.8	-1.2
Perennial ryegrass	112.3 A[Y] a[Z]	72.7 A b	39.7 A c	5.8 A d
Creeping bentgrass	98.5 A a	53.1 B b	5.6 C c	0.3 B c
Zoysiagrass	104.4 A a	29.6 C b	13.7 B c	1.7 B d
Tall fescue	99.1 A a	26.4 C b	5.6 C c	0.5 B c
Bermudagrass	88.5 A a	25.3 C b	3.0 C c	0.0 B c
Kentucky bluegrass	99.3 A a	15.3 C b	3.6 C b	0.0 B b

[Y] Uppercase letters indicated differences of turfgrass species under each drought level at $P \leq 0.05$.
[Z] Lowercase letters indicated differences of drought levels within turfgrass species at $P \leq 0.05$.