Enhancing Creeping Bentgrass Drought Tolerance with Gamma Amino Butyric Acid Application.

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Introduction:

Gamma aminobutyric acid (GABA) is a non-protein amino acid known to accumulate in plants under drought stress (Shelp et al., 2012). Several studies suggest that GABA often rapidly accumulates in plants in response to abiotic and biotic stresses including drought, salt, wounding, hypoxia, heat shock, and pathogen infection (Kinnersley and Turano, 2000). Whether GABA may influence the antioxidant response and impact turfgrass physiological responses to abiotic stress deserves investigation. The objectives of the study were to evaluate the effects of exogenous applications of GABA on the response of creeping bentgrass to drought stress conditions on a physiological basis and to evaluate the effects on hormonal, antioxidant and nutrient responses.

Material and methods:

Growth condition and treatments:

A growth chamber study was conducted to evaluate the effect of GABA in mitigating the drought stress response in creeping bentgrass cultivar 'Penncross'. Plant were grown in 6 inch plastic pots filled with sandy loam soil (sand 71%: Silt 17 %: Clay 12%) and allowed to establish in growth chamber before applying the treatments. GABA was applied as a foliar spray at the rate of 50 mM under well watered or drought conditions. The treatments were arranged in a completely randomized design with 4 replication and measurements were taken at 2, 5 and 7 days after treatment.

Penncross plants before treatment

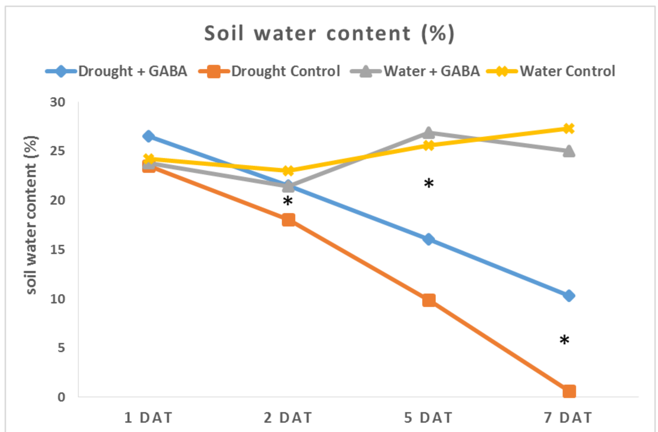

Fig.1: Soil water content of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.

Results

RWC was 113 and 100% higher in drought stressed plants treated with 50 mM GABA than in non-treated plants at 5 and 7 days after treatment. GABA treated plants showed better turf quality (2.3 and 4 fold) at 5 and 7 DAT respectively than control under drought. Significantly higher FV/FM (5.4 fold) and Yield (8 fold) was observed in GABA treated plants compared to drought control at 7 DAT. The CTD was higher in drought stressed plants treated with GABA at 5 DAT (10 fold) and 7 DAT (3 fold). Lower EL was observed in plant treated with GABA at 5 DAT (42%) and 7 DAT (25%) under drought.

Leaf ABA was significantly higher in GABA treated drought stressed plants at 2 DAT (3 fold) and 5 DAT (32 fold) compared to control. GABA treated plants showed higher IAA content at 5 DAT (6.6 fold) and 7 DAT (2.6 fold) compared to control under drought. SA levels were 8 fold higher at 7 DAT in GABA treated plants compared to control under drought.

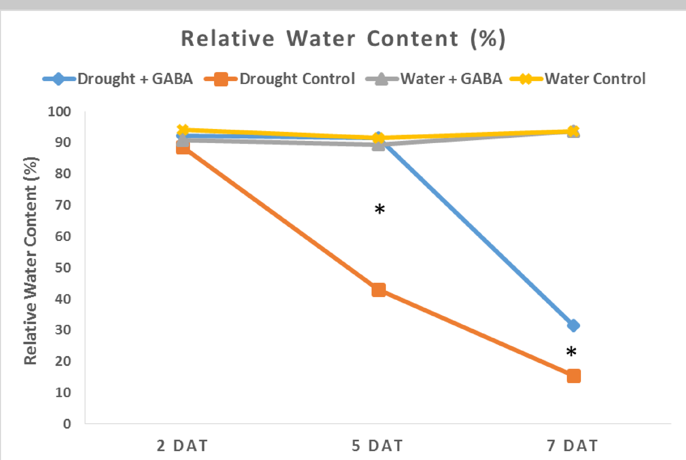

Fig.2: Relative water content of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.

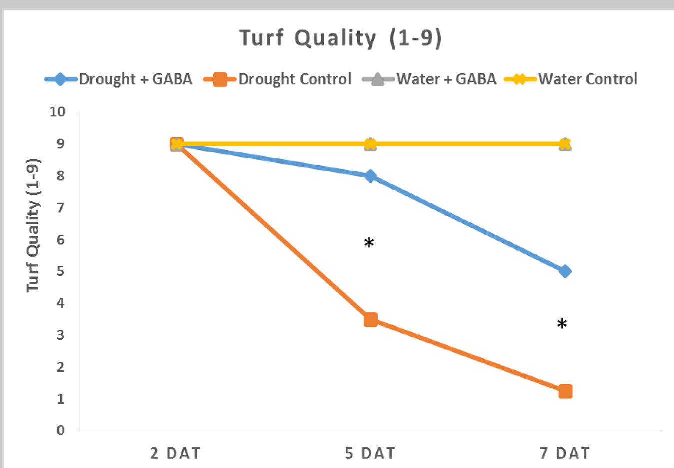

Fig.3: Turf quality (9= healthy, 1= necrotic) of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.

Acknowledgement:

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Results

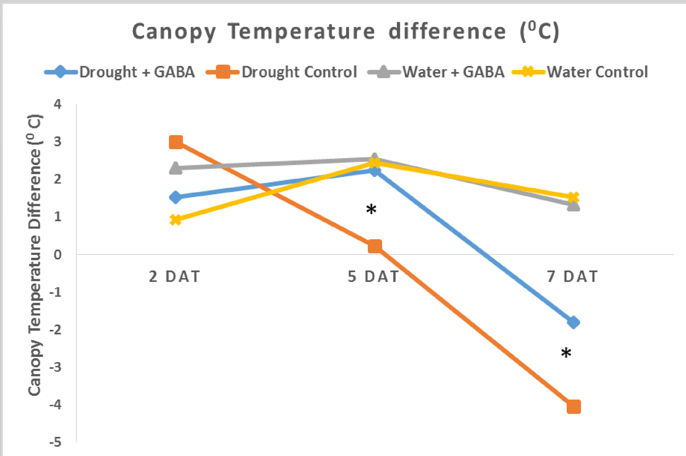


Fig.4: Canopy temperature depression of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.

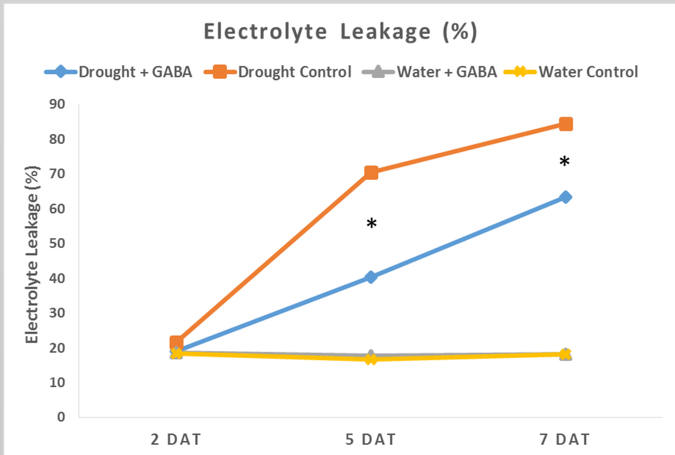


Fig.5: Electrolyte leakage of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.

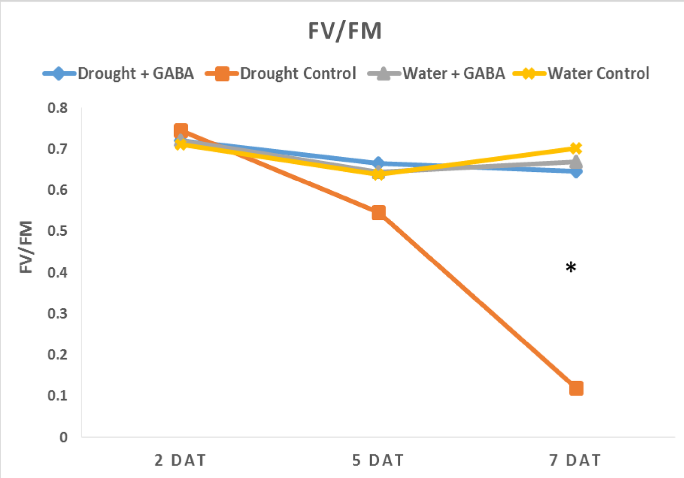


Fig.6: FV/FM of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.

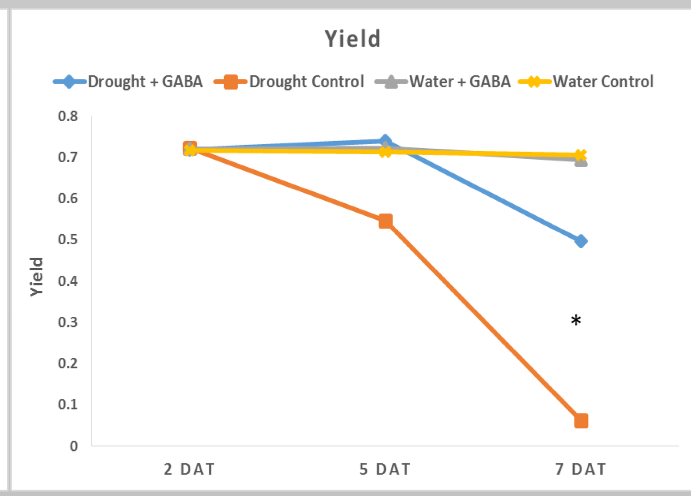
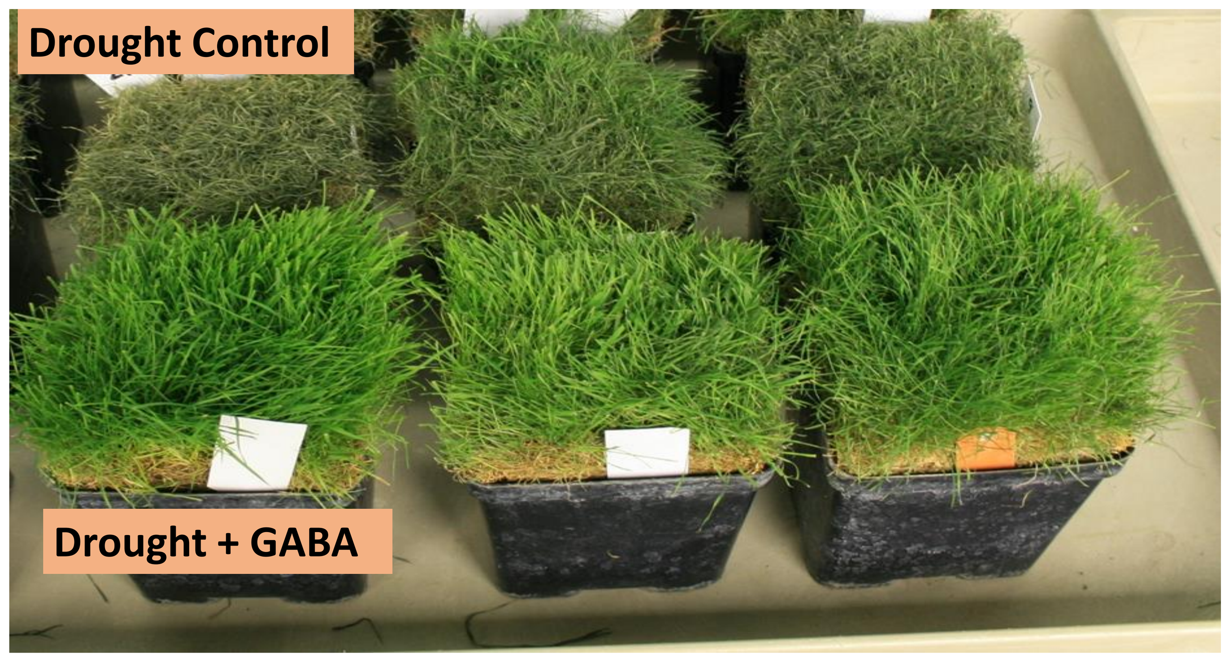
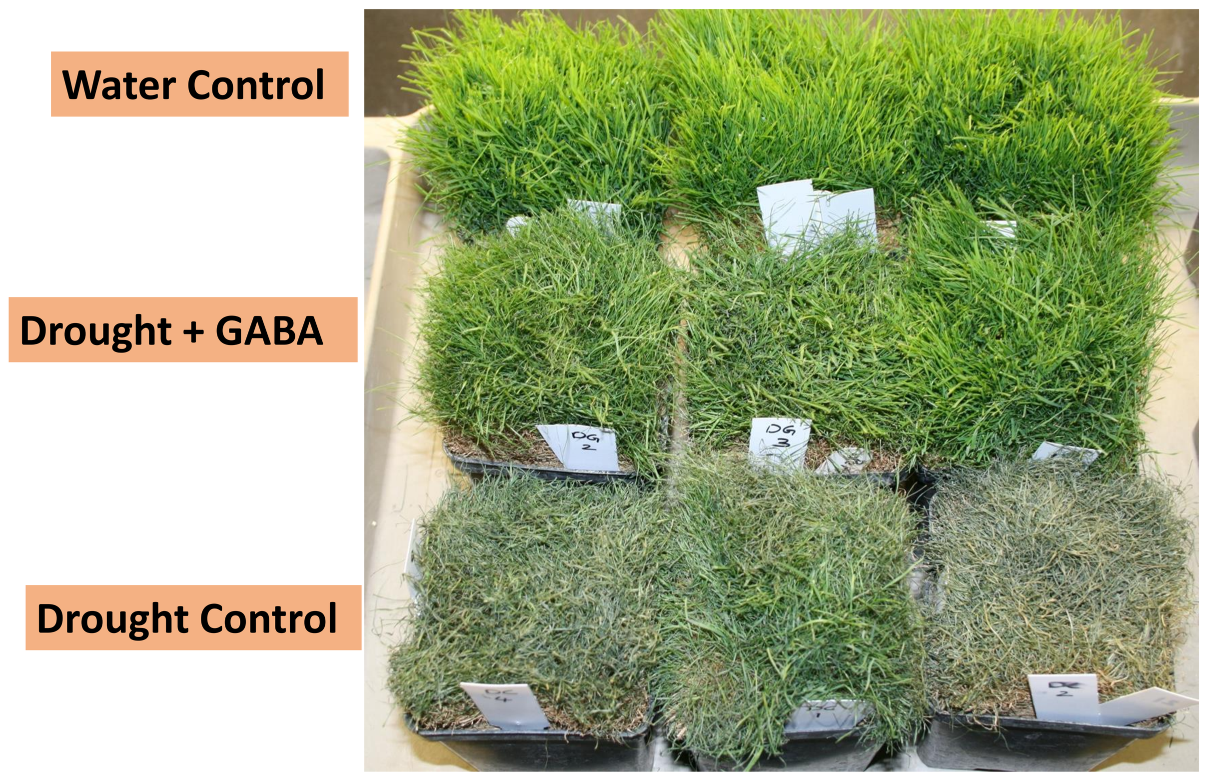


Fig.7: Yield (PS II) of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.





Quattro Premier LC/MS

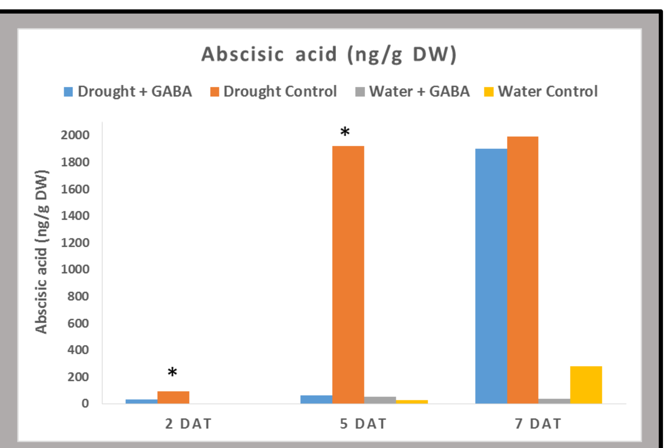


Fig.8: Endogenous leaf abscisic acid content of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.

Hormone Analysis:

Approximately 200 mg of frozen tissue sample was homogenized and mixed with 850 uL cold extraction buffer (methanol: water: acetic acid, 80:19:1, v/v/v) and vigorously shaken on a shaking bed for 16 h at 4^0C in the dark, and centrifuged at 14,000 rpm for 20 min at 4^0C. The supernatant was transferred to a new 1.5 mL tube, and pellet was remixed with 400 uL extraction buffer, shaken at 4^0C in the dark for 4 h, and centrifuged at 14,000 rpm for 20 min at 4^0C. The supernatant from the two tubes was mixed and dried using centrifugal vacuum concentrator and then dissolved in 200 uL methanol. One hundred nano moles of deuterium labeled internal standard of ABA was added at the time of extraction. Liquid chromatography was carried out using Waters Quattro Premier XE mass spectrometer (UPLC/MS/MS; ACQUITY Tandem Quadrupole, Waters, MA).

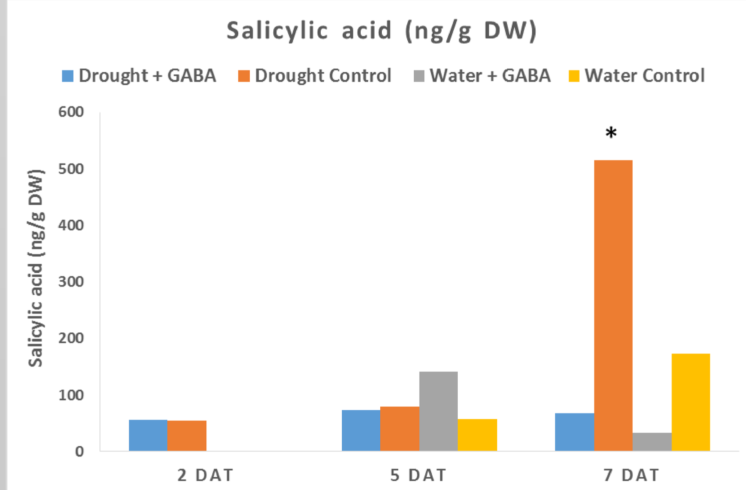


Fig.9: Endogenous leaf salicylic acid content of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.

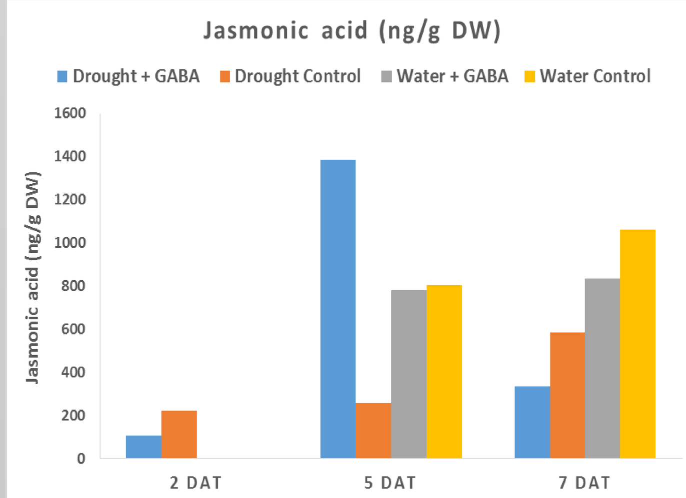


Fig.10: Endogenous leaf jasmonic acid content of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.

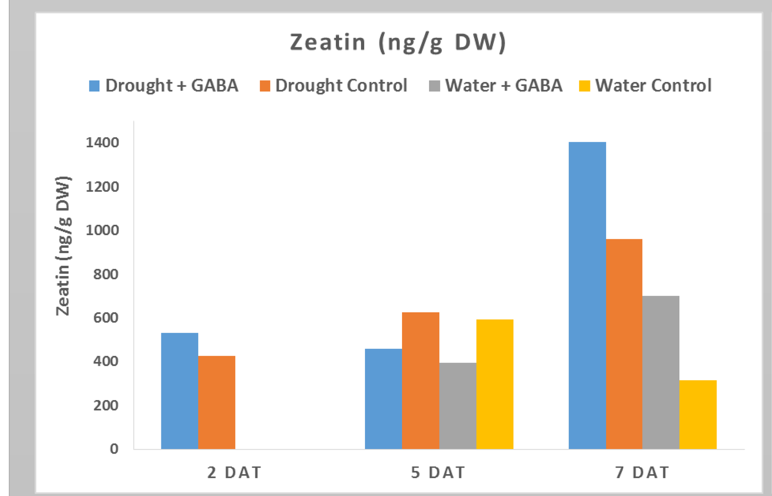


Fig.11: Endogenous leaf zeatin content of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.

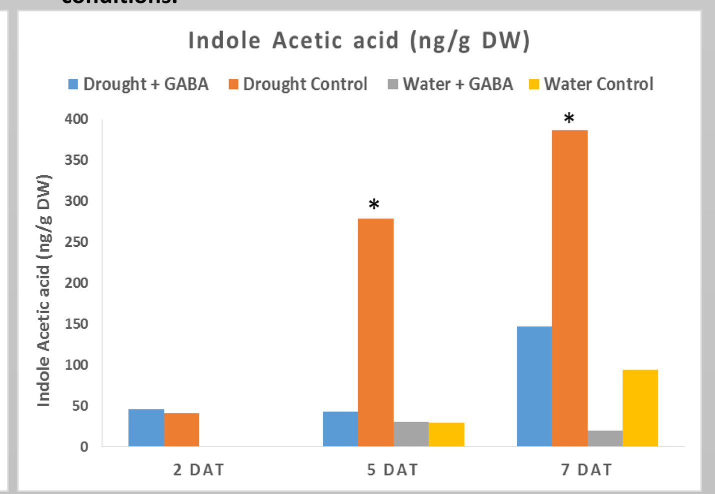


Fig.12: Endogenous leaf Indole acetic acid content of creeping bentgrass 'Penncross' treated with g-aminobutyric acid (GABA) at the rate of 50 mM under well-watered and drought conditions.

Conclusion:

GABA treated plants performed better under drought compared to untreated plants based on results from growth physiology. We found significantly higher up-regulation of ABA (2 and 5 DAT), IAA (5 and 7 DAT) and SA (7 DAT) in drought stressed GABA treated plants compared to control. Exogenous GABA application has been shown to impart abiotic stress tolerance in plants including drought. Previous studies suggest that GABA could act as a signaling molecule and involve in phytohormone regulation such as ABA, IAA and ethylene. (Lancein and Roberts, 2006). The results from the current study suggest that phytohormones regulation could play a major role in mitigating the drought stress response in GABA treated bentgrass.

References

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