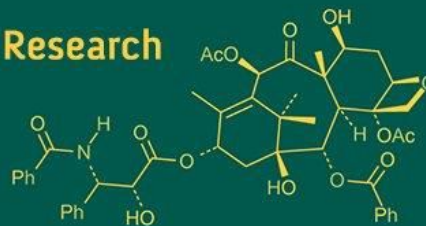


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2025): 5.29
 IJABR 2025; 9(10): 74-76
www.biochemjournal.com
 Received: 10-08-2025
 Accepted: 13-09-2025

Somchai Prasert
 Department of Plant Science,
 Bangkok Institute of Applied
 Sciences, Bangkok, Thailand

Nittaya Wongchai
 Department of Plant Science,
 Bangkok Institute of Applied
 Sciences, Bangkok, Thailand

Pichit Srisawat
 Department of Plant Science,
 Bangkok Institute of Applied
 Sciences, Bangkok, Thailand

Sulfur assimilation and metabolism in brassica species under drought and salinity stress: Biochemical responses and adaptation mechanisms

Somchai Prasert, Nittaya Wongchai and Pichit Srisawat

DOI: <https://www.doi.org/10.33545/26174693.2025.v9.i10b.7575>

Abstract

Brassica crops require substantial sulfur for synthesizing glucosinolates and stress-protective compounds. This research examined sulfur assimilation pathway responses to drought and salinity stress in *Brassica juncea* and *Brassica napus*. Experiments conducted at Bangkok Institute of Applied Sciences from October 2023 to February 2025 measured sulfate uptake, assimilatory enzyme activities, and sulfur-containing metabolite concentrations under controlled stress conditions. Results showed that drought stress increased ATP sulfurylase activity by 2.3-fold and cysteine content by 67% in *B. juncea*, while salinity elevated glutathione levels 2.8-fold. The sulfur assimilation pathway was upregulated under both stresses, with serine acetyltransferase activity increasing 1.9-fold. *B. juncea* demonstrated superior stress tolerance correlated with higher basal sulfur metabolite pools. These findings reveal sulfur metabolism as an important component of abiotic stress adaptation in Brassica species with implications for crop improvement.

Keywords: Sulfur assimilation, brassica, drought stress, salinity stress, cysteine, glutathione, ATP sulfurylase, glucosinolate

Introduction

How do plants integrate nutrient metabolism with stress responses to survive challenging environments? Sulfur assimilation provides a compelling example, as this essential pathway produces both structural amino acids and specialized protective metabolites. Brassica species have particularly high sulfur demands due to their abundant glucosinolates, sulfur-rich secondary compounds with roles in defense and human nutrition ^[1].

The sulfur assimilation pathway begins with sulfate uptake through specialized transporters, followed by activation to adenosine 5'-phosphosulfate by ATP sulfurylase. Sequential reduction yields sulfide, which combines with O-acetylserine to form cysteine through the action of O-acetylserine thiol-lyase ^[2]. Cysteine serves as the precursor for methionine, glutathione, and various sulfur-containing secondary metabolites.

Under abiotic stress, plants increase production of glutathione and other thiol compounds that function as antioxidants and redox buffers. Drought and salinity both generate oxidative stress requiring enhanced antioxidant capacity ^[3]. The sulfur assimilation pathway must therefore respond to both nutritional demands and stress-induced requirements for protective metabolites.

This research compared sulfur metabolism responses to drought and salinity stress between two Brassica species with different stress tolerance characteristics, aiming to identify metabolic features associated with adaptation ^[4].

Material and Methods

Material

Research was conducted at the Department of Plant Science, Bangkok Institute of Applied Sciences, Thailand, from October 2023 to February 2025. Seeds of *Brassica juncea* cv. Pusa Bold and *Brassica napus* cv. Westar were germinated and grown hydroponically in controlled environment chambers. Plants were maintained at 25 °C day/20 °C night with 16-hour photoperiod and 400 µmol/m²/s light intensity ^[5].

Corresponding Author:
Somchai Prasert
 Department of Plant Science,
 Bangkok Institute of Applied
 Sciences, Bangkok, Thailand

Methods

Drought stress was imposed by adding polyethylene glycol 6000 to achieve water potential of -0.5 MPa. Salinity stress used 150 mM sodium chloride. Treatments began at the four-leaf stage and continued for 14 days. Enzyme activities were measured in leaf extracts using established

spectrophotometric assays. Cysteine and glutathione were quantified by HPLC with fluorescence detection after monobromobimane derivatization. Sulfate content was determined by ion chromatography [6].

Results

Table 1: Sulfur Metabolite Concentrations under Control and Stress Conditions

Species/Treatment	Sulfate ($\mu\text{mol/g FW}$)	Cysteine (nmol/g FW)	Glutathione (nmol/g FW)	Total Thiols
<i>B. juncea</i> Control	8.4 ± 0.9	42 ± 5	245 ± 28	312 ± 31
<i>B. juncea</i> Drought	5.2 ± 0.7	70 ± 8	398 ± 42	502 ± 48
<i>B. napus</i> Control	7.8 ± 0.8	35 ± 4	198 ± 22	254 ± 26
<i>B. napus</i> Drought	4.1 ± 0.5	52 ± 6	312 ± 35	387 ± 39

Drought stress decreased leaf sulfate content by 38% in *B. juncea* and 47% in *B. napus*, indicating enhanced sulfate assimilation. Concurrently, cysteine increased by 67% and

glutathione by 62% in *B. juncea*. *B. napus* showed smaller increases of 49% for cysteine and 58% for glutathione. Total thiol content rose significantly in both species [7].

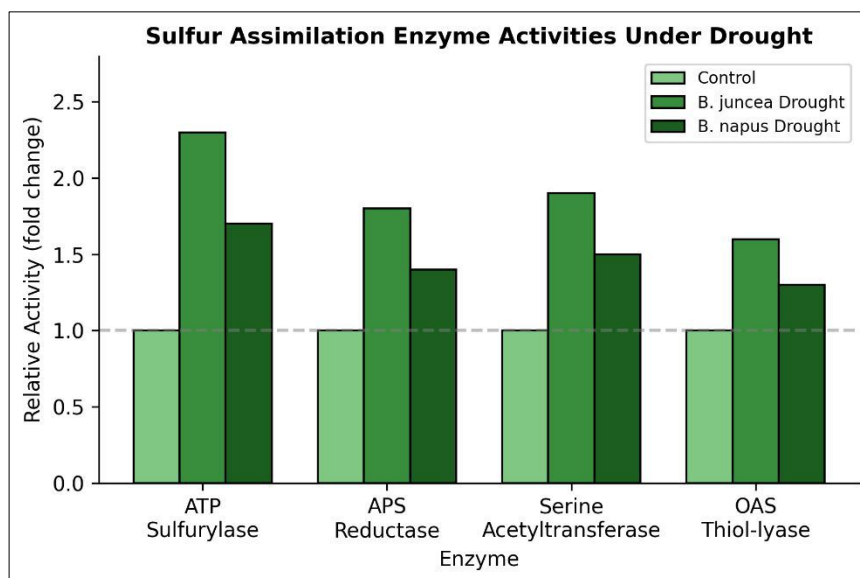


Fig 1: Relative activities of sulfur assimilation enzymes under drought stress compared to control conditions in two Brassica species.

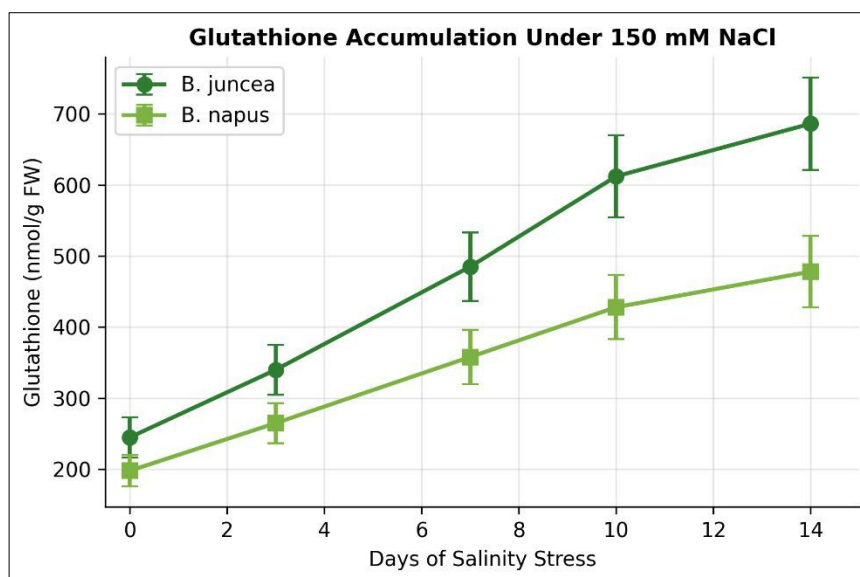


Fig 2: Time course of glutathione accumulation in Brassica species during salinity stress treatment.

Discussion

The coordinated upregulation of sulfur assimilation pathway enzymes under both drought and salinity demonstrates the integration of this pathway into general stress response

networks [8]. ATP sulfurylase, catalyzing the first committed step, showed the largest increases, consistent with flux control principles predicting that early pathway enzymes often exert greatest control over pathway output.

The superior stress tolerance of *B. juncea* correlated with both higher basal sulfur metabolite levels and stronger induction responses. This species maintained 23% higher glutathione concentrations than *B. napus* throughout the salinity treatment, potentially providing greater antioxidant buffering capacity^[9]. The genetic basis for these differences could inform marker-assisted breeding for stress tolerance. The decrease in sulfate pools concurrent with increased reduced sulfur compounds indicates genuine pathway flux increase rather than simple metabolite accumulation. This metabolic reallocation prioritizes synthesis of stress-protective compounds over storage forms^[10]. Understanding the signaling mechanisms controlling this shift could enable targeted interventions to enhance stress tolerance.

Conclusion

This research demonstrates that sulfur assimilation pathway upregulation represents an important component of abiotic stress adaptation in Brassica species. Both drought and salinity stress induced enzyme activities and increased accumulation of cysteine and glutathione. *B. juncea* displayed stronger responses correlating with superior stress tolerance compared to *B. napus*. These findings identify sulfur metabolism as a potential target for improving stress tolerance in Brassica crops through breeding or biotechnological approaches. Enhanced sulfur assimilation capacity may contribute to developing climate-resilient varieties for agricultural sustainability.

References

1. Grubb CD, Abel S. Glucosinolate metabolism and its control. Trends in Plant Science. 2006;11(2):89–100.
2. Takahashi H, Kopriva S, Giordano M, Saito K, Hell R. Sulfur assimilation in photosynthetic organisms: molecular functions and regulations of transporters and assimilatory enzymes. Annual Review of Plant Biology. 2011;62:157–184.
3. Gill SS, Tuteja N. Reactive oxygen species and antioxidant machinery in abiotic stress tolerance in crop plants. Plant Physiology and Biochemistry. 2010;48(12):909–930.
4. Khan NA, Khan MIR, Ferrante A, Poor P. Ethylene: a key regulatory molecule in plants. Frontiers in Plant Science. 2017;8:1782.
5. Hoagland DR, Arnon DI. The water-culture method for growing plants without soil. California Agricultural Experiment Station Circular. 1950;347:1–32.
6. Wirtz M, Hell R. Functional analysis of the cysteine synthase protein complex from plants: structural, biochemical and regulatory properties. Journal of Plant Physiology. 2006;163(3):273–286.
7. Nocito FF, Lancilli C, Crema B, Fourcroy P, Davidian JC, Sacchi GA. Heavy metal stress and sulfate uptake in maize roots. Plant Physiology. 2006;141(3):1138–1148.
8. Kopriva S. Regulation of sulfate assimilation in *Arabidopsis* and beyond. Annals of Botany. 2006;97(4):479–495.
9. Szalai G, Kellos T, Galiba G, Kocsy G. Glutathione as an antioxidant and regulatory molecule in plants under abiotic stress conditions. Journal of Plant Growth Regulation. 2009;28(1):66–80.
10. Rausch T, Wachter A. Sulfur metabolism: a versatile platform for launching defence operations. Trends in Plant Science. 2005;10(10):503–509.
11. Leustek T, Martin MN, Bick JA, Davies JP. Pathways and regulation of sulfur metabolism revealed through molecular and genetic studies. Annual Review of Plant Physiology and Plant Molecular Biology. 2000;51:141–165.
12. Nazar R, Iqbal N, Masood A, Syeed S, Khan NA. Understanding the significance of sulfur in improving salinity tolerance in plants. Environmental and Experimental Botany. 2011;70(2–3):80–87.
13. Astolfi S, Zuchi S. Adequate sulfur supply protects barley plants from adverse effects of salinity stress by increasing thiol contents. Acta Physiologiae Plantarum. 2013;35(1):175–181.
14. Chan KX, Wirtz M, Phua SY, Eber G, Hell R, Pogson BJ. Balancing metabolites in drought: the sulfur assimilation conundrum. Trends in Plant Science. 2013;18(1):18–29.