Brassinosteroids: A Comprehensive Review of its Applications in Agriculture and Horticulture

Abstract

Brassinosteroids (BRs) are a class of plant steroid hormones that regulate growth, development, and stress responses. Since the discovery of brassinolide in *Brassica napus* pollen, BRs have emerged as critical regulators of crop productivity and resilience. This review synthesizes recent advances in BR research, focusing on their physiological roles, applications in agriculture, and future prospects for sustainable farming.

Keywords: Brassinosteroids, Agriculture, Horticulture, Yield, Quality, Biotic, Abiotic stress

1. Introduction

Plant hormones, or phytohormones, are naturally occurring chemical messengers that regulate plant growth, development, and responses to environmental stimuli, making them indispensable in agriculture and horticulture. These signaling molecules, including auxins, gibberellins, cytokinins, abscisic acid, and ethylene, orchestrate processes such as seed germination, root and shoot growth, flowering, fruit ripening, and stress adaptation (Raynott, 2023). Their application in crop production has revolutionized practices by enhancing yield, improving quality, and enabling precise management of plant physiology (Table 1) (~~Achanta~~ Rama, 2025). In horticulture, plant hormones are widely used to control flowering time, induce rooting in cuttings, delay senescence, and synchronize fruit ripening, thereby improving both productivity and market value. By integrating hormonal regulation into modern cultivation systems, farmers and horticulturists can optimize plant performance under diverse environmental conditions, ensuring sustainable and efficient production (Abdel-Latif et al., 2018).

Brassinosteroids (BRs) are a class of plant steroidal hormones that regulate key physiological processes such as cell elongation, division, seed germination, flowering, and stress tolerance, making them vital for crop growth and productivity. Their application in agriculture has been shown to enhance plant development, improve yield, and increase resilience against abiotic stresses like drought, salinity, and extreme temperatures. Recent studies highlight their role in modulating agronomic traits through BR-related genes, positioning them as promising targets for crop breeding and biotechnological interventions aimed at sustainable agriculture. By improving photosynthetic efficiency, nutrient uptake, and stress adaptation, brassinosteroids contribute significantly to food security and agricultural innovation (~~Xu~~ Chen et al., 2024; Chakraborty et al., 2025; tong et al., 2018)

Table 1: Comparative Roles of Major Plant Hormones

Hormone	Primary Function	Stress Role	Agricultural Use
Auxins	Cell elongation, root initiation	Limited	Rooting agents
Gibberellins	Stem elongation, seed germination	Moderate	Fruit set
Cytokinins	Cell division, delay senescence	Moderate	Tissue culture

Abscisic Acid	Stress signaling, stomatal closure	High (drought tolerance)	Stress management
Ethylene	Fruit ripening, senescence	Moderate	Ripening control
Brassinosteroids	Growth, photosynthesis, stress tolerance	Very high (abiotic & biotic)	Yield & resilience

2. Chemical Nature and Biosynthesis

Brassinosteroids (BRs) are a unique class of polyhydroxylated steroidal plant hormones structurally similar to animal steroid hormones. They consist of about 70 known derivatives of sterols, characterized by a rigid steroid backbone with hydroxyl substitutions that confer biological activity. These compounds are ubiquitously present in low concentrations across plant tissues, including seeds, pollen, leaves, and roots. Functionally, BRs regulate diverse physiological processes such as cell elongation, vascular differentiation, reproductive development, and stress responses, making them essential for normal plant growth and adaptation (Oklestkova et al., 2015).

The biosynthesis of brassinosteroids originates from campesterol, a common plant sterol, through a complex network of oxidative modifications (Fig.1). This pathway involves multiple cytochrome P450-dependent monooxygenases and reductases, leading to the formation of bioactive BRs such as brassinolide, the most potent member of the group. The biosynthetic route can proceed via two main branches: the early C-6 oxidation pathway and the late C-6 oxidation pathway, both converging at intermediates like castasterone before producing brassinolide. Regulation of these pathways ensures BR homeostasis, balancing growth promotion with environmental adaptation (**Oklestkova et al., 2015; Bajguz et al., 2020**).

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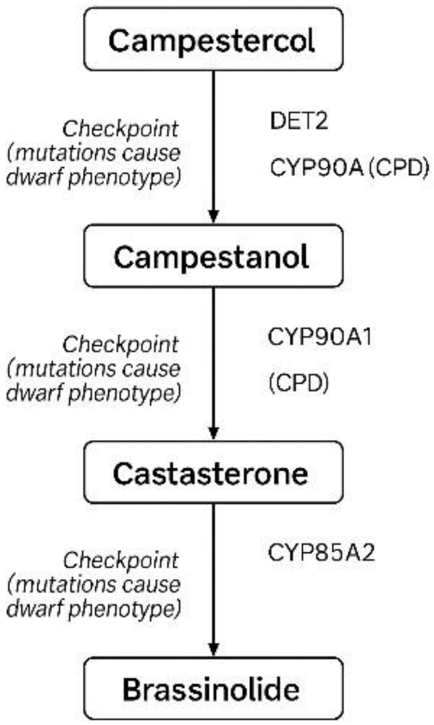

Figure 1: Proposed biosynthetic pathway of brassinosteroids

3. Physiological Roles of Brassinosteroids

Brassinosteroids play diverse physiological roles in plants, acting as essential steroidal hormones that regulate growth, development, and stress responses. They promote cell elongation and division, vascular differentiation, and seed germination, while also enhancing flowering, fruit set, and senescence regulation. BRs interact synergistically with other phytohormones such as auxins, gibberellins, and cytokinins to coordinate developmental processes, and they modulate photosynthesis and nutrient uptake to improve plant productivity. Importantly, they strengthen plant defense mechanisms against biotic stresses like pathogens and pests, and confer tolerance to abiotic stresses including drought, salinity, extreme temperatures, and heavy metal toxicity, thereby ensuring overall plant resilience and adaptability. Reference? Manghvar et al., 2022

Brassinosteroids (BRs) are essential plant steroid hormones that regulate cell elongation and division by modulating gene expression and signaling pathways involved in growth. They promote cell expansion through loosening of the cell wall and activation of enzymes such as expansins, while simultaneously stimulating cell cycle progression by upregulating cyclin-dependent kinases and other division-related genes. Mutant studies deficient in BR biosynthesis or signaling consistently show dwarfism and reduced cell proliferation, highlighting their indispensable role in both elongation and mitotic activity. Overall, BRs act as master regulators integrating hormonal and environmental cues to coordinate plant growth and development at the cellular level (Chakraborty et al., 2025).2025a

Brassinosteroids play a pivotal role in root development by regulating both cell division in the meristematic zone and cell elongation in the differentiation zone, thereby shaping root architecture and growth. They enhance root meristem activity by promoting the expression of cell cycle regulators, while also influencing auxin transport and signaling to coordinate root patterning. BRs stimulate root hair formation, which improves nutrient and water uptake, and they interact with other hormones such as auxins and cytokinins to fine-tune root growth under varying environmental conditions. Mutants defective in BR biosynthesis or signaling often exhibit shortened roots and impaired meristem activity, underscoring their essential role in root system establishment and adaptability (~~Brigitte~~ Poppenberger et al., 2024; Meena et al., 2021; Manghwar et al., 2022).

Brassinosteroids significantly enhance photosynthesis by regulating chlorophyll biosynthesis, stabilizing photosystem II (PSII) proteins, and improving carbon assimilation efficiency. They prevent the degradation of photosynthetic pigments by inducing enzymes involved in chlorophyll synthesis, thereby maintaining higher pigment levels under stress conditions. BRs also stabilize the D1 protein of PSII, which is crucial for sustaining photochemical efficiency, and they increase Rubisco activity, leading to improved CO_2 fixation and carbohydrate metabolism. Experimental applications of 24-epibrassinolide in cucumber plants have shown marked increases in net CO_2 assimilation rates, chlorophyll fluorescence, and overall photosynthetic capacity, confirming their role as potent regulators of photosynthetic performance and plant productivity (Siddiqui et al., 2018; ~~Jing Quan~~ Yu et al., 2004).

Brassinosteroids are vital regulators of reproductive growth in plants, influencing processes from floral initiation to seed and fruit development. They promote pollen viability and tube elongation, enhance ovule development, and ensure successful fertilization, thereby directly impacting yield potential. BRs also modulate gene expression linked to flower organ identity and reproductive tissue differentiation, while interacting with auxin and gibberellin pathways to coordinate reproductive organ growth. Mutants deficient in BR biosynthesis or signaling often display male sterility, reduced seed set, and impaired fruit formation, underscoring their indispensable role in reproductive success. Recent studies highlight that BRs not only regulate gametophyte development but also contribute to fruit maturation and seed filling, making them central to reproductive fitness and agricultural productivity (~~Rita B~~ Lima et al., 2024; Aryal et al., 2025).

Brassinosteroids are key hormonal regulators that enhance plant stress tolerance by modulating antioxidant defense systems, stabilizing membranes, and maintaining photosynthetic efficiency under adverse conditions. They mitigate abiotic stresses such as drought, salinity, and cold by reducing reactive oxygen species (ROS) accumulation through the activation of antioxidant enzymes like superoxide dismutase and catalase, while also improving osmolyte accumulation to maintain cellular homeostasis. BRs interact with other phytohormones, including abscisic acid and auxin, to fine-tune stress responses and promote adaptive growth. Experimental evidence shows that BR application increases freezing tolerance in temperate plants and alleviates salt-induced growth inhibition, underscoring their role as central players in stress resilience and environmental adaptation (Anwar et al., 2018; ~~Ramirez~~ Veronica et al., 2020).

4. Applications in Agriculture

Brassinosteroids have promising agricultural applications, as they stimulate plant growth and development by enhancing cell elongation, division, and seed germination. They improve crop yield and quality by promoting flowering, fruit set, and stress resilience under adverse conditions (Figure 2). BRs also strengthen plant defense against pathogens and pests, reducing reliance on chemical pesticides. Overall, their eco-friendly nature positions them as sustainable growth regulators for modern agriculture and horticulture (Table 2).

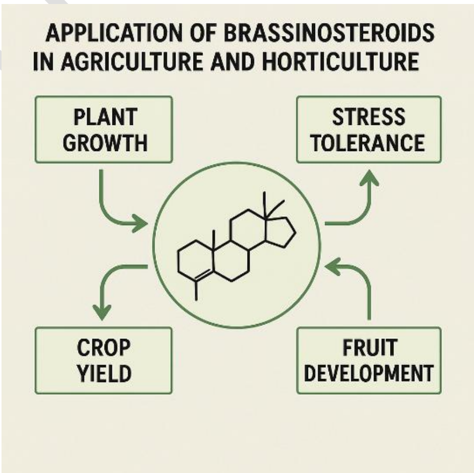

Figure 2: Brassinosteroids application in agriculture

4.1 Crop Yield Enhancement

Brassinosteroids have emerged as powerful tools for crop yield improvement due to their ability to regulate multiple agronomic traits, including plant architecture, biomass accumulation, and reproductive success. By enhancing cell elongation, division, and chlorophyll biosynthesis, BRs improve photosynthetic efficiency and overall plant vigor, leading to higher yields. They also modulate hormone crosstalk with auxins and gibberellins, fine-tuning processes such as flowering, seed filling, and fruit development. Genetic studies have shown that manipulation of BR-related genes can optimize plant height, tiller number, and grain size, making BRs valuable targets for crop breeding programs aimed at yield enhancement.Lin, 2020

Nolan et al., 2020

Unterholzner et al 2015.,

Beyond growth regulation, BRs contribute to yield stability under stress conditions by enhancing tolerance to drought, salinity, and temperature extremes. Their application as plant growth regulators has been shown to improve root architecture, nutrient uptake, and water-use efficiency, which are critical for sustaining productivity in challenging environments. Field trials and experimental studies demonstrate that exogenous BR treatments increase grain yield in cereals and improve fruit set in horticultural crops, while breeding approaches targeting BR signaling pathways hold promise for developing high-yielding, stress-resilient varieties. Thus, BRs represent a dual strategy for crop yield improvement—boosting productivity under optimal conditions and safeguarding yields under stress. Divi and Krishna 2009

Vikram et al., 2022

Khripach et al., 2000

Epibrassinolide (EBL), a biologically active brassinosteroid, has been shown to improve fruit size and quality in horticultural crops by enhancing growth, yield, and nutritional parameters. Foliar application of 24-epibrassinolide in strawberries significantly increased plant growth, fruit weight, and improved quality attributes such as sugar content and firmness, leading to better market value. Similarly, in table grapes, EBL treatment enhanced phytochemical contents, including phenolics and antioxidants, while improving overall fruit quality parameters. These findings highlight EBL's potential as an eco-friendly plant growth regulator that not only boosts fruit size but also enriches nutritional and sensory qualities, making it a promising tool for sustainable horticultural production (Li et al., 2022; Ali et al., 2022).

Here too you need more relevant references

4.2 Abiotic Stress Management

Brassinosteroids are widely recognized for their role in mitigating drought stress in crops by enhancing physiological and biochemical resilience. Exogenous application of BRs improves photosynthetic efficiency, stabilizes chlorophyll content, and activates antioxidant defense systems, thereby reducing oxidative damage caused by water deficit. They also promote osmotic adjustment through increased accumulation of osmolytes such as proline and soluble sugars, which help maintain cell turgor under drought conditions. Studies in maize have shown that BR treatment upregulates antioxidant enzymes and improves water-use efficiency, leading to better growth and yield under limited water availability (Figure 3). Practical applications in agriculture highlight that BRs not only alleviate drought-induced growth inhibition but also contribute to sustainable crop productivity under climate stress scenarios (El-Beltagi et al., 2025). ✓

(Farooq et al., 2009)

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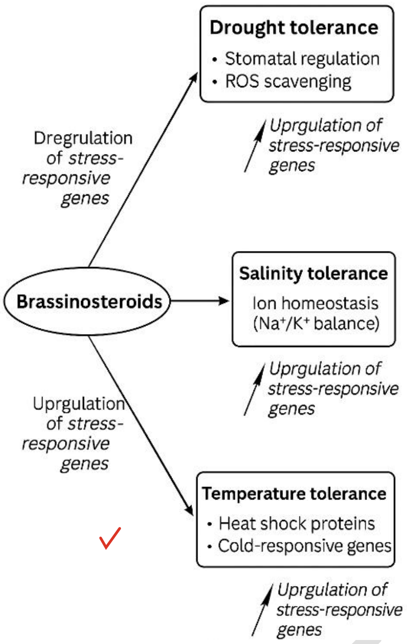

Figure 3: Mechanisms of BR-mediated abiotic stress tolerance.

Brassinosteroids play a crucial role in alleviating salinity stress in crops by enhancing physiological and biochemical mechanisms that sustain growth under high salt conditions. Exogenous application of BRs improves ion homeostasis by reducing sodium (Na^+) accumulation and maintaining potassium (K^+) levels, thereby protecting cellular functions. They also activate antioxidant defense systems, mitigating oxidative damage caused by salt-induced reactive oxygen species (ROS), while promoting osmolyte accumulation such as proline and soluble sugars to stabilize membranes and maintain osmotic balance. Studies have shown that BR treatments enhance photosynthetic efficiency, root growth, and nutrient uptake in salt-stressed plants, ultimately leading to improved yield and quality in cereals and horticultural crops. These findings underscore the potential of BRs as eco-friendly plant growth regulators for managing salinity stress and ensuring sustainable crop productivity (Vikram et al.,2022; Anjum et al., 2019).

Brassinosteroids, particularly epibrassinolide, are effective in mitigating the adverse effects of temperature extremes in crops by enhancing physiological resilience and protecting cellular structures. Under heat stress, BRs stabilize photosynthetic machinery, reduce oxidative damage by activating antioxidant enzymes, and maintain membrane integrity, thereby sustaining growth and yield. In cold stress conditions, they improve chlorophyll retention, enhance osmolyte accumulation, and upregulate stress-responsive genes, which collectively increase freezing tolerance. Studies confirm that BRs induce tolerance against both extreme cold and heat by modulating hormonal crosstalk and stress signaling pathways, making them valuable eco-friendly regulators for safeguarding crop productivity under fluctuating climatic conditions (Priya pandey et al., 2025; Siddique et al., 2025; Chaudhuri et al., 2022).

Table 2: Agricultural Applications of Brassinosteroids

Application Area	Effect of BRs	Example Crops
Yield enhancement	Increased biomass, grain yield	Rice, wheat

Fruit quality	Larger size, improved nutritional value	Tomato, mango
Drought tolerance	Better water-use efficiency	Maize, soybean
Salinity tolerance	Reduced oxidative damage	Rice, barley
Pathogen resistance	Activation of defense pathways	Tomato, cucumber
Post-harvest quality	Delayed senescence, extended shelf life	Apple, banana

4.4 Post-Harvest Applications

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Brassinosteroids have promising applications in postharvest management of crops by improving fruit quality, extending shelf life, and reducing losses. Postharvest application of BRs delays senescence by maintaining chlorophyll content, reducing ethylene production, and enhancing antioxidant activity, which helps preserve freshness and nutritional value. They also regulate ripening processes in both climacteric and non-climacteric fruits, influencing color development and texture while minimizing physiological disorders. Studies highlight that BRs improve stress tolerance during storage, reduce microbial spoilage, and maintain higher levels of phytochemicals such as phenolics and antioxidants, thereby enhancing both safety and marketability of fruits and vegetables. These eco-friendly molecules thus represent a sustainable approach to postharvest quality management in horticultural crops (Siddique at al., 2021; Garrido-Auñón et al., 2024)Chakraborty et al., 2025b

4.5 Applications in Horticulture and Ornamentals

Brassinosteroids, a class of plant steroidal hormones, have emerged as potent growth regulators in horticulture and ornamental crops due to their multifaceted roles in plant physiology. They enhance seed germination, regulate flower sex expression, stimulate flowering, and improve fruit set and development, thereby boosting both yield and quality. In ornamentals, BRs promote vegetative growth, flowering intensity, and stress tolerance, making them valuable for improving aesthetic appeal and marketability. Moreover, their application mitigates the effects of abiotic stresses such as drought, salinity, and temperature extremes, while also strengthening resistance against biotic stresses. Structurally modified analogues of BRs with greater stability are now commercially available, further expanding their practical utility in horticultural production systems and ornamental crop management **(Kang and Guo, 2011; Zhang et al., 2023).**

Why bold?

5. Challenges and Limitations

Brassinosteroids face several challenges and limitations (Tabel 3) that hinder their widespread agricultural adoption, primarily due to the high cost of synthesis, which makes large-scale production economically unfeasible for many farming systems. Their effectiveness also shows considerable field variability, as plant responses differ across species, cultivars, and environmental conditions, complicating standardization of application practices. In addition, regulatory hurdles remain a significant barrier, with limited approvals and stringent safety evaluations restricting their commercial use compared to conventional synthetic growth regulators. Together, these factors highlight the need for cost-effective production methods, deeper understanding of species-specific responses, and streamlined regulatory frameworks to fully realize the potential of brassinosteroids in sustainable agriculture and horticulture.

Table 3: Challenges and Future Prospects in use of brassinosteroids

Challenge	Current Limitation	Future Direction
Cost of synthesis	Expensive chemical production	Biotechnological synthesis
Field variability	Species-specific responses	Precision agriculture tools
Regulatory hurdles	Limited approval for use	Policy integration
Delivery methods	Inefficient foliar sprays	Nanotechnology-based delivery

6. Future Prospects

Brassinosteroids hold significant promise for future agricultural and horticultural innovation, with biotechnological approaches such as genetic engineering and CRISPR/Cas-mediated editing of BR biosynthesis and signaling pathways enabling the development of stress-resilient, high-yielding, and nutritionally enhanced crops. In precision agriculture, integration with nanotechnology can facilitate targeted and controlled delivery of BRs, ensuring efficient use and minimizing wastage while allowing real-time regulation through sensor-based systems. As eco-friendly alternatives to synthetic growth regulators, BRs align with sustainable farming practices by improving productivity without compromising soil health or biodiversity, making them suitable for organic cultivation. Beyond these roles, BRs are poised to contribute to climate-smart agriculture, food security, and horticultural advancements such as enhanced fruit quality, shelf life, and ornamental plant growth, thereby positioning them as key drivers of sustainable crop improvement in the coming decades.

7. Conclusion

Brassinosteroids represent a powerful tool in modern agriculture, capable of enhancing yield, improving stress tolerance, and supporting sustainable practices. Continued research into their biosynthesis, signaling, and field applications will be critical for harnessing their full potential in global food security.

References

Abdel-Latif H.H., N.G. Shams El-Din, H.A.H. Ibrahim, Antimicrobial activity of the newly recorded red alga *Grateloupia doryphora* collected from the Eastern Harbor, Alexandria, Egypt, *Journal of Applied Microbiology*, Volume 125, Issue 5, 1 November 2018, Pages 1321–1332, https://doi.org/10.1111/jam.14050

Achanta Rama (2025). From Seed to Harvest: How Plant Hormones Drive Growth and Agricultural Innovation. AgriBio Innovations, 2(1): 44-48.

Ali, M.M., Anwar, R., Malik, A.U. *et al.* Plant Growth and Fruit Quality Response of Strawberry is Improved After Exogenous Application of 24-Epibrassinolide. *J Plant Growth Regul* 41, 1786–1799 (2022). https://doi.org/10.1007/s00344-021-10422-2

Anjum, S.A., Wang, L.C., Farooq, M., Khan, I., Xue, L., & Ali, S. (2019). Advances on exogenous applications of brassinosteroids. *Australian Journal of Crop Science*, 13(1), 115–121. doi:10.21475/ajcs.19.13.01.p1404.

Anwar, A., Liu, Y., Dong, R., Bai, L., Yu, X., & Li, Y. (2018). The physiological and molecular mechanism of brassinosteroid in response to stress: a review. Biological research, 51.

Aryal, D., & Alferez, F. (2025). Brassinosteroids: Biosynthesis, Signaling, and Hormonal Crosstalk as Related to Fruit Yield and Quality. *Plants*, *14*(12), 1865. https://doi.org/10.3390/plants14121865.

Bajguz A, Chmur M and Gruszka D (2020) Comprehensive Overview of the Brassinosteroid Biosynthesis Pathways: Substrates, Products, Inhibitors, and Connections. *Front. Plant Sci.* 11:1034. doi: 10.3389/fpls.2020.01034.

Brigitte Poppenberger, Eugenia Russinova, Sigal Savaldi-Goldstein, Brassinosteroids in Focus, *Plant and Cell Physiology*, Volume 65, Issue 10, October 2024, Pages 1495–1499, https://doi.org/10.1093/pcp/pcae112

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Chakraborty, N., Ganguly, R., Sarkar, A. *et al.* Multifunctional Role of Brassinosteroids in Plant Growth, Development, and Defense. *J Plant Growth Regul* 44, 2627–2640 (2025). https://doi.org/10.1007/s00344-024-11593-4.

2025 a Chakraborty, N., Ganguly, R., Sarkar, A., Dasgupta, D., Sarkar, J., Acharya, K., Burachevskaya, M., Minkina, T., & Keswani, C. (2025). *Multifunctional Role of Brassinosteroids in Plant Growth, Development, and Defense*. J. Plant Growth Regulation, 44, 2627–2640.

2025 b Chakraborty, S., Saha, D.P., Malini, K., Lenka, B., Balo, S., Murmu, D.K., Sangma, N.M., & Mani, A. (2025). *Post-harvest application of brassinosteroids: A review of its effects on fruit quality, nutritional value and safety*. Int. J. Adv. Biochem. Res., 9(3), Part H.

Chaudhuri, A., Halder, K., Abdin, M. Z., Majee, M., & Datta, A. (2022). Abiotic Stress Tolerance in Plants: Brassinosteroids Navigate Competently. *International Journal of Molecular Sciences*, *23*(23), 14577. https://doi.org/10.3390/ijms232314577.

El-Beltagi, H.S., Sattar, A., Sher, A. *et al.* Exogenous Application of Silicon and Brassinosteroids Alleviate the Adversities of Drought Stress on Maize through Up-Regulation of Photosynthetic Efficiency, Antioxidants Defense System and Osmotic Adjustment. *Russ J Plant Physiol* 72, 84 (2025). https://doi.org/10.1134/S102144372461022X.

Garrido-Auñón, F., Puente-Moreno, J., García-Pastor, M. E., Serrano, M., & Valero, D. (2024). Brassinosteroids: An Innovative Compound Family That Could Affect the Growth, Ripening, Quality, and Postharvest Storage of Fleshy Fruits. *Plants*, *13*(21), 3082. https://doi.org/10.3390/plants13213082.

Jing Quan Yu, Li Feng Huang, Wen Hai Hu, Yan Hong Zhou, Wei Hua Mao, Su Feng Ye, Salvador Nogués, A role for brassinosteroids in the regulation of photosynthesis in *Cucumis sativus*, *Journal of Experimental Botany*, Volume 55, Issue 399, 1 May 2004, Pages 1135–1143, https://doi.org/10.1093/jxb/erh124.

Kang, Y.Y., Guo, S.R. (2011). Role of brassinosteroids on horticultural crops. In: Hayat, S., Ahmad, A. (eds) Brassinosteroids: A Class of Plant Hormone. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-0189-2_9.

Li J, Javed HU, Wu Z, Wang L, Han J, Zhang Y, Ma C, Jiu S, Zhang C and Wang S (2022) Improving berry quality and antioxidant ability in 'Ruidu Hongyu' grapevine through preharvest exogenous 2,4-epibrassinolide, jasmonic acid and their signaling inhibitors by regulating endogenous phytohormones. *Front. Plant Sci.* 13:1035022. doi: 10.3389/fpls.2022.1035022.

Lin W-H (2020) Designed Manipulation of the Brassinosteroid Signal to Enhance Crop Yield. *Front. Plant Sci.* 11:854. doi: 10.3389/fpls.2020.00854.

Manghwar, H., Hussain, A., Ali, Q., & Liu, F. (2022). Brassinosteroids (BRs) Role in Plant Development and Coping with Different Stresses. *International Journal of Molecular Sciences*, *23*(3), 1012. https://doi.org/10.3390/ijms23031012.

Meena, S.,Nagar, S and Meena, MK (2021) Brassinosteroids: A novel phytohormone regulating root growth in plants. *Food and Scientific Reports*. 2 (9) 43-51.

Oklestkova, J., Rárová, L., Kvasnica, M. *et al.* Brassinosteroids: synthesis and biological activities. *Phytochem Rev* 14, 1053–1072 (2015). https://doi.org/10.1007/s11101-015-9446-9.

Ramirez Veronica E. , Poppenberger Brigitte. 2020. Modes of Brassinosteroid Activity in Cold Stress Tolerance. Frontiers in Plant Science. DOI=10.3389/fpls.2020.583666.

Not cited in the text

Raynott W (2023) Functions and Applications of Plant Hormones in Horticulture. J Hortic. 10:329.

Rita B Lima, Duarte D Figueiredo, Sex on Steroids: How Brassinosteroids Shape Reproductive Development in Flowering Plants, *Plant and Cell Physiology*, Volume 65, Issue 10, October 2024, Pages 1581–1600, https://doi.org/10.1093/pcp/pcae050.

Siddiqui, H., Hayat, S. & Bajguz, A. Regulation of photosynthesis by brassinosteroids in plants. *Acta Physiol Plant* 40, 59 (2018). https://doi.org/10.1007/s11738-018-2639-2

Tong, Hongning, Chu, Chengcai 2018. Functional Specificities of Brassinosteroid and Potential Utilization for Crop Improvement. Trends in Plant Science. 1360-1385. doi: 10.1016/j.tplants.2018.08.007.

Vikram et al. (2022). Role of Brassinosteroids in plants responses to salinity stress: A review. Journal of Applied and Natural Science, 14(2), 582 - 599. https://doi.org/10.31018/jans.v14i2.3466.

Xu Chen, Xiaotong Hu, Jianjun Jiang, Xuelu Wang, Functions and Mechanisms of Brassinosteroids in Regulating Crop Agronomic Traits, *Plant and Cell Physiology*, Volume 65, Issue 10, October 2024, Pages 1568–1580, https://doi.org/10.1093/pcp/pcae044.

Not cited in the text

Yang, Yanzhao, Chu, Chengcai, Qian, Qian, Tong, Hongning, 2023. Leveraging brassinosteroids towards the next Green Revolution. doi: 10.1016/j.tplants.2023.09.005.

Zhang Z, Chen Z, Song H and Cheng S (2023) From plant survival to thriving: exploring the miracle of brassinosteroids for boosting abiotic stress resilience in horticultural crops. *Front. Plant Sci.* 14:1218229. doi: 10.3389/fpls.2023.1218229