International Journal of Research Publication and Reviews, Vol 6, Issue 7, pp 6543-6547 July 2025

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

The Golden Crop: Review of *Brassica Campestris* in Global Agriculture

Dr. Amrit jindal, [1]Dr. Vidhi Sharma, [2]Dr. Rajesh Sharma

*[1] PG Scholar (Ayu). Dravyaguna Department, A & U Tibbia College & Hospital, Karol Bagh, New Delhi.

[2] Professor (Ayu), H.O.D, Dravyaguna Department, A & U Tibbia College, Karol Bagh, New Delhi.

ABSTRACT

Brassica campestris, commonly known as yellow mustard or rapeseed, is a valuable crop of the Brassicaceae family, cultivated primarily for its oil-rich seeds used in food, biofuel, and health-related applications. Rich in essential fatty acids, vitamins, and phytochemicals like glucosinolates, it holds potential for both nutritional and medicinal benefits. Rising global demand, driven by food security concerns amid climate change and population growth, underscores the need for advanced breeding techniques and sustainable cultivation. This article discusses its taxonomy and classification, morphological characteristics, genetic diversity, nutritional and medicinal properties, ecological impact, and current research methodologies. Taxonomic inconsistencies across major botanical databases highlight the complexity of its classification, emphasizing the importance of genomic studies to guide breeding and conservation efforts. While genetically modified (GM) variants have improved productivity through pest and herbicide resistance, they also raise ecological and ethical debates regarding biodiversity and food safety. As agriculture faces mounting environmental challenges, *Brassica campestris* remains a key species in research aimed at improving crop resilience and sustainability.

Keywords: - Brassica campestris, yellow mustard, oilseed crops, genetic diversity, glucosinolates, sustainable agriculture, agricultural biotechnology

Taxonomy and Classification

The taxonomy of the genus Brassica, including Brassica campestris, has been a subject of ongoing research and debate among plant taxonomists. As of October 2022, the Integrated Taxonomic Information System (ITIS) recognizes 13 subordinate taxa within the species rank of Brassica [1]. This contrasts with other taxonomic resources, such as the World Flora Online project, which acknowledges 41 species of Brassica [1]. The discrepancies in species recognition highlight significant challenges in the classification of Brassica taxa, particularly at lower taxonomic levels such as subspecies, cultivars, and varieties, which can vary depending on the author or gene bank consulted [1]. A notable repository, Brassi Base, aims to enhance taxonomic and evolutionary understanding specifically within the Brassicaceae family, reporting 45 species of Brassica [1]. This effort underscores the complexities of nomenclature and the necessity for standardized taxonomic frameworks. Moreover, the Germplasm Resources Information Network (GRIN) also lists 41 Brassica species, although its categorizations do not entirely align with the World Checklist of Seed Plants, leading to further inconsistencies across various databases [1]. In an attempt to address the taxonomic uncertainties, the integration of phenotypic, geographical, and genomic data has been proposed to develop a universal molecular passport for Brassica species [2]. This approach could potentially streamline breeding programs and enhance the identification of useful genetic variations. Recent advancements in genomic technologies have also provided valuable resources for the classification and breeding of Brassica species, enabling more precise taxonomic assignments based on genetic sequencing [1, 2]. The ongoing efforts in refining the classification of Brassica campestris and its relatives exemplify the need for collaboration among taxonomists and geneticists to develop a more cohesive and universally accepted framework

Morphological Characteristics

Brassica campestris, commonly known as yellow mustard, exhibits a range of distinctive morphological traits that define its classification within the Brassicaceae family. The flowers of this species are actinomorphic and hermaphrodite, featuring a characteristic cruciform arrangement of four petals and sepals that are separate and not fused [3]. The style and stigma are notably short and bifid, while the flowers themselves are radially symmetrical, a trait that facilitates effective pollination [3]. Fruit Structure The fruit of Brassica campestris is a silique, which is a specific type of dry fruit that dehisces (splits open) upon ripening, typically measuring 20–110 mm in length and 2–5 mm in width [4]. Each fruit contains two locules, with seeds arranged in a single row per locule. The fruits are cylindrical, with parallel sides and a flat top and bottom, and they typically orient upward or curve outward from the stem [4]. Leaf Morphology The leaves of Brassica campestris are simple, alternate, and exhibit an expanded blade texture, ranging in width from 30 to 200 mm [4]. They feature an entire margin without teeth or lobes, and their shape can vary from acute to obtuse at the tip [4]. The leaf stalk, or petiole, attaches at the basal margin of the leaf blade, which can sometimes clasp the stem [4].

Additional Characteristics

In terms of anatomical features, Brassica campestris has a parietal placentation, where ovules develop on the wall of the ovary, creating a structure that is characteristic of the Brassicaceae family [3, 4]. The seeds themselves are relatively small, measuring between 1–1.8 mm, and are hairless, smooth, or may exhibit reticulate markings on their surface [4]. These morphological traits not only facilitate the identification of Brassica campestris but also underline its adaptability and ecological roles within various environments, particularly in terrestrial habitats across New England [4]

Genetic Diversity

Genetic diversity is a critical component in the breeding and improvement of Brassica campestris, as it provides the essential genetic resources needed to develop resilient and high-yielding varieties. Molecular genetic diversity studies utilizing simple sequence repeat primer pairs have identified a significant number of alleles at poly morphic loci, which can be used to inform breeding strategies aimed at enhancing traits of interest [5]. Characterizing this genetic diversity enables breeders to select beneficial alleles and identify markers associated with desirable traits, facilitating their introgression into cultivated varieties [6]. The increasing demands for global food security, driven by population growth and cli mate change, necessitate a re-evaluation of crop production practices. It is estimated that to adequately feed a projected global population of 10 billion by 2050, staple crop yields must increase by 70-110% [2]. Traditional plant breeding has relied on the collection and rearrangement of genetic diversity followed by phenotypic selection; however, this approach has limitations, including extended timeframes for variety development and challenges in improving complex traits [2]. The exploitation of available genetic diversity is foundational for plant improvement, with elite varieties, land races, and wild species serving as vital sources of useful variation. The conservation of this diversity within gene banks and natural populations is crucial for sustaining future breeding efforts [7]. Additionally, the identification of suitable parental lines and alleles plays a key role in the development of Brassica crops that can withstand abiotic stresses such as heat, drought, and salinity, all of which are increasingly important due to climate change [8, 9]. Furthermore, genomics has the potential to enhance our understanding of the genetic origins and molecular pathways related to stress tolerance in Brassica species. By mapping the genetic inheritance of beneficial traits, breeders can more effectively track and utilize variation for crop improvement. However, the process of modern breeding can inadvertently lead to the loss of genetic diversity and increased homogeneity, which may compromise the resilience of crops to environmental changes. Employing comparative population genomics can help identify selective sweeps and genetic bottlenecks, ensuring that valuable genetic variation is not lost.

Cultivation and Agriculture

Brassica campestris, commonly known as rapeseed or canola, is an important agricultural crop with a variety of applications, including vegetable oil production and as a biofumigant for pest and disease management in agriculture [10]. The cultivation of this crop has significantly evolved, particularly through the integration of genetic modification (GM) technologies that have enhanced weed and insect control, allowing farmers to achieve higher yields while utilizing fewer resources. For instance, the adoption of herbicide-tolerant GM varieties has contributed to a cumulative global income gain estimated at $6.44 billion since 1996 [2].

Global Food Security Challenges

As the world faces predictions of exponential population growth and climate change impacts, the cultivation of crops like Brassica campestris is increasingly crucial for global food security. It is projected that staple crop yields need to increase by 70–110% by 2050 to adequately feed a global population expected to reach 10 Billion [2]. The agricultural sector must adapt to these challenges by improving crop resilience to biotic and abiotic stresses, which are exacerbated by climate change, such as heat, drought, and salinity [2]. The integration of cross-disciplinary approaches involving breeders, climate specialists, and crop modelers is essential to align breeding objectives with the increasing complexity of environmental factors affecting crop production [2].

Pest and Disease Management

In terms of pest and disease management, an integrated pest management (IPM) strategy is commonly employed, combining various methods such as cultural practices, chemical controls, and the use of resistant cultivars. Effective management of common pests and pathogens affecting Brassica crops—such as black rot, clubroot, and downy mildew—requires a multifaceted approach, as no single method is sufficient on its own [11]. For example, cultural controls like field sanitation and weed removal are often effective yet require careful implementation to avoid disrupting local biodiversity [11]. Research has shown that early sowing of Brassica plants can significantly reduce the severity of clubroot disease and improve yield, highlighting the importance of timing in crop management strategies [11]. Additionally, practices such as longer crop rotations and intercropping with specific species can further mitigate disease pressure on Brassica crops, thereby enhancing overall productivity [11]

Nutritional and Medicinal Properties

Brassica campestris, commonly known as rapeseed or mustard greens, is recognized for its rich nutritional profile and various health benefits. The plant is abundant in essential fatty acids, particularly omega-3 and omega-6, along with a plethora of antioxidants, vitamins, and minerals, which collectively contribute to its health-promoting properties [12, 13].

Nutritional Composition

Brassica campestris is particularly notable for its high content of vitamins such as C, K, and folate, as well as dietary minerals and fibre [13]. The presence of beneficial phytochemicals, including phenolic compounds, glucosinolates, and carotenoids, enhances its nutritional significance, promoting overall health [14, 15]. Specifically, mustard greens are recognized for providing substantial amounts of vitamin K, which is essential for blood clotting and bone health, with cooked varieties delivering even higher concentrations [16].

Antioxidant Activity

The antioxidant capacity of Brassica campestris has been a focal point of research, with studies indicating that its extracts exhibit strong radical-scavenging abilities [17, 18]. Antioxidants present in the plant, such as flavonoids and beta-carotene, play a critical role in combating oxidative stress, a condition linked to chronic diseases like cancer and cardiovascular ailments [18, 19]. In vitro analyses have demonstrated that anthocyanin-rich varieties of Brassica, such as purple mustard, significantly outperform other cultivars in antioxidant activity, further supporting their incorporation into health-conscious diets [17].

Health Benefits

Brassica campestris offers a wide array of health benefits, including potential anti-cancer effects. Some studies suggest that components like glucosinolates may help protect cells against DNA damage and impede the growth of cancerous cells, although further research in human subjects is warranted to confirm these effects [16, 20]. Additionally, the plant's high vitamin C content boosts the immune system, while its antioxidants may help reduce the risk of diseases associated with oxidative stress, including heart disease, type 2 diabetes, and neurodegenerative conditions [16, 19].

Ecological Impact

Role in Soil Health and Biodiversity Brassica campestris plays a significant role in maintaining soil health and promoting biodiversity within its ecosystem. The cultivation of this species enhances positive plant–microbe–rhizosphere interactions, which are essential for nutrient availability, reducing soil erosion, and improving soil structure [21]. Furthermore, the application of beneficial microbes associated with Brassica crops has a historical precedent, having been shown to mitigate both biotic and abiotic stresses in plants, thus contributing to improved crop resilience [8].

Contribution to Global Food Security

The global demand for food is projected to escalate due to an increasing population and climate change challenges. Plant crops, including Brassica species, account for over 80% of human dietary intake and occupy nearly half of the world's arable land [2]. Consequently, the cultivation of Brassica campestris is vital not only for its economic significance, with a combined gross production value estimated at $67.5 billion in 2020, but also for its potential to contribute to food security by improving crop yields amidst environmental pressures [1]. Future crop improvement strategies will prioritize traits that enhance resilience to abiotic stresses such as heat, drought, and salinity, all of which are increasingly relevant in the face of climate change [2].

Conservation of Plant Genetic Resources

The genetic diversity of Brassica species is crucial for sustainable agricultural practices. However, climate change and habitat destruction have posed significant threats to plant genetic resources, including Brassica campestris [1, 2]. Conservation efforts through gene banks and protected areas are essential for preserving these resources and preventing biodiversity loss. By prioritizing the conservation of plant genetic resources, including wild relatives of Brassica, researchers can enhance genetic diversity and contribute to the resilience of agricultural systems against changing environmental conditions [1, 2].

Interactions with Pollinators and Herbivores

Brassica campestris also interacts with various organisms within its ecosystem. Pollinators, particularly honeybees, play a vital role in enhancing the reproductive fitness of Brassica species, which in turn leads to improved yield attributes [22, 23]. However, these crops are also susceptible to herbivory, with certain insect species capable of causing significant damage, especially during critical growth stages [24]. Effective pest management strategies are necessary to mitigate these impacts and support the overall health of Brassica populations and their surrounding ecosystems.

Future Considerations

The need for innovative agricultural practices that integrate the ecological roles of Brassica campestris with modern crop improvement techniques is critical. Advances in genomic technologies and high-throughput phenotyping are essential to enhance our understanding of Brassica's interactions within its environment and improve its resilience to climate-induced challenges [2, 25]. Through these efforts, Brassica campestris can continue to serve as a cornerstone of sustainable agriculture and contribute to global food security

Findings and Discussion

Health Benefits of Brassica Campestris

Brassica campestris, commonly known as canola or rapeseed, exhibits a variety of health benefits attributed to its rich content of glucosinolates and other phytochemicals. These compounds have demonstrated potential anticancer properties through mechanisms that include the induction of detoxification enzymes and protection against oxidative stress, which can decrease the risk of certain cancers, including stomach, colorectal, and ovarian cancers [26].

Disease Management Strategies

The review highlights the critical role of integrated pest management (IPM) strategies tailored to specific geographic locations for the effective control of diseases affecting brassicas. It emphasizes that no single control method is universally effective; instead, a combination of cultural practices and limited chemical controls is necessary [11]. Furthermore, the research identifies several knowledge gaps regarding the biology and lifecycle of causal pathogens, thereby recommending future studies to enhance disease management practices in Brassica cultivation [11].

Transitioning Approaches in Conservation

The transition from a traditional genetics approach to a conservation genomics framework is poised to significantly enhance future conservation recommendations and policies pertaining to Brassica species. This approach is anticipated to provide a more comprehensive understanding of genetic diversity and adaptability, which is essential for the sustainable management of these crops in the face of climate change and other environmental challenges [2].

References

1. Subramanian P, Kim SH, Hahn BS. Brassica biodiversity conservation: prevailing constraints and future avenues for sustainable distribution of plant genetic resources. Front Plant Sci. 2023 Jul 27; 14:1220134. doi: 10.3389/fpls.2023.1220134.
2. Saad NSM, Severn-Ellis AA, Pradhan A, Edwards D, Batley J. Genomics armed with diversity leads the way in Brassica improvement in a changing global environment. Front Genet. 2021 Feb 18; 12:600789. doi: 10.3389/fgene.2021.600789.
3. Https://www.vedantu.com/question-answer/most-important-character-of-brassica-campestris-class-11-biology-cbse-5f5a7a5b73443a0884d21de6
4. Native Plant Trust. Brassica rapa (rape): Go Botany [Internet]. Framingham (MA): Native Plant Trust; [cited 2025 Jul 28]. Available from: https://gobotany.nativeplanttrust.org/species/brassica/rapa/
5. Guo Y, Chen S, Li Z, Cowling WA. Center of origin and centers of diversity in an ancient crop, Brassica rapa (Turnip Rape). J Hered. 2014 Jul-Aug;105(4):555-565. doi: https://doi.org/10.1093/jhered/esu021
6. Saad NSM, Severn-Ellis AA, Pradhan A, Edwards D, Batley J. Genomics armed with diversity leads the way in Brassica improvement in a changing global environment. Front Genet. 2021 Feb 18; 12:600789. doi: 10.3389/fgene.2021.600789.
7. Ullah Z, Ali K, Wadood SF, Khan W, Nisar M. Estimation of genetic diversity in the germplasm of Brassica campestris (L.) using morphological and biochemical markers. J Bot. 2019 Oct;1(1):45-58. doi: 10.33195/uochjb-v1i1332017.
8. Khalid M, Hassani D, Bilal M, Liao J, Huang D. Elevation of secondary metabolites synthesis in Brassica campestris ssp. chinensis L. via exogenous inoculation of Piriformospora indica with appropriate fertilizer. PLoS One. 2017 May 11;12(5):e0177185. doi: 10.1371/journal.pone.0177185.
9. Lee NH, Jeong W, Jung JY, Han J, Baek M, Son M, Byeon JH, Hwang ET, Kim KH. Effect of abiotic stresses on Brassica rapa production in Korea: Learning from history to better prepare for the future impacts of climate change. Agric Syst. 2025; 228:104374. doi: 10.1016/j.agsy.2025.104374.
10. The Crop Trust. Brassicas - Crop Trust [Internet]. Bonn: The Crop Trust; 2023 Jul 19 [cited 2025 Jul 28]. Available from: https://www.croptrust.org/news-events/campaigns/crop-conservation-strategies/brassicas/
11. Greer SF, Surendran A, Grant M, Lillywhite R. The current status, challenges, and future perspectives for managing diseases of brassicas. Front Microbiology. 2023 Jul 18; 14:1209258. doi: 10.3389/fmicb.2023.1209258.
12. The Special Chem. Brassica Campestris Seed Oil (Rapeseed): Cosmetic Ingredient INCI [Internet]. [cited 2025 Jul 28]. Available from: https://www.specialchem.com/cosmetics/inci-ingredients/brassica-campestris-seed-oil
13. Quora. Why are plants in Brassica so popular as food? [Internet]. [cited 2025 Jul 28]. Available from: https://www.quora.com/Why-are-plants-in-Brassica-so-popular-as-food
14. Hedges LJ, Lister CE. Nutritional attributes of Brassica vegetables. Crop & Food Research Report No. 1618. 2006 Jan.

15. Allender, C., Giovannini, P. 2023. Global Strategy for the Conservation of Brassica Genetic Resources. Global Crop Diversity Trust. Bonn, Germany. DOI: 10.5281/zenodo.7544810

16. Warwick KW, McGrane K. Mustard greens: nutrition facts and health benefits. Medically reviewed by Kathy W. Warwick, RDN, CDCES. Nutrition. 2020 Mar 25.

17. Li X, Wang F, Ta N, Huang J. The compositions, characteristics, health benefits and applications of anthocyanins in Brassica crops. Front Plant Sci. 2025 Feb 17; 16:1544099. doi: 10.3389/fpls.2025.1544099.

18. Rahman M, Khatun A, Liu L, Barkla BJ. Brassicaceae mustards: phytochemical constituents, pharmacological effects, and mechanisms of action against human disease. Int J Mol Sci. 2024 Aug 20;25(16):9039. doi: 10.3390/ijms25169039.

19. Favela-González KM, Hernández-Almanza AY, De la Fuente-Salcido NM. The value of bioactive compounds of cruciferous vegetables (Brassica) as antimicrobials and antioxidants: A review. J Food Biochem. 2020 Aug 3;44(8):e13414. doi: 10.1111/jfbc.13414.

20. Gonçalves EM, Alegria C, Abreu M. Benefits of Brassica nutraceutical compounds in human health. In: Lang M, editor. Brassicaceae: Characterization, functional genomics and health benefits. Nova Publishers, Inc.; 2013. p. 19-65.

21. Ullah Z, Ali K, Wadood SF, Khan W, Nisar M. Growth response of Brassica campestris with plant growth-promoting bacteria selected in vitro. [Internet]. ResearchGate; 2019 [cited 2025 Jul 28]. Available from: https://www.researchgate.net/figure/Growth-response-of-Brassica-campestris-with-plant-growth-promoting-bacteria-selected-in_fig2_342680028

22. Bruckman, D. (2015). Mechanisms for pollinator-mediated interactions between native and invasive plants. *UC Irvine*. ProQuest ID: Bruckman_uci_0030D_13297. Merritt ID: ark:/13030/m5tm9k48. Retrieved from https://escholarship.org/uc/item/95v835q6

23. Rijal SP, Thapa RB, Sharma MD, Sah SK, Gc YD. Pollinators diversity and their effects on rapeseed (Brassica campestris L. var. toria) production and productivity in Chitwan, Nepal. J Agric Environ. 2018; 18:151. doi: 10.3126/aej.v18i0.19900.

24. The Khethari. Rapeseed and mustard cultivation practices [Internet]. [cited 2025 Jul 28]. Available from: https://www.khethari.com/blogs/news/rapeseed-and-mustard-cultivation-practices

25. Subramanian P, Kim SH, Hahn BS. Brassica biodiversity conservation: prevailing constraints and future avenues for sustainable distribution of plant genetic resources. Front Plant Sci. 2023 Jul 27; 14:1220134. doi: 10.3389/fpls.2023.1220134.

26. Kapusta-Duch J, Kopeć A, Piatkowska E, Borczak B, Leszczyńska T. The beneficial effects of Brassica vegetables on human health. Rocz Panstw Zakl Hig. 2012;63(4):389-95. PMID: 23631258.