REVIEW

FUTURE PERSPECTIVES FOR PEST AND DISEASE MANAGEMENT IN BRASSICA: A REVIEW

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INTRODUCTION

Brassica oleracea L. has been cultivated for centuries and holds cultural significance in various regions (Candolle 2021). Is a highly nutritious vegetable, rich in essential vitamins (such as vitamin C, vitamin K, and vitamin B6), minerals (including potassium, calcium, and iron), and dietary fiber. It is a low-calorie food and is known for its potential health benefits, including its role in promoting digestive health and supporting the immune system (Ebabhi and Adebayo 2022; Siddeeg et al. 2022; Kumar et al. 2020;). Cabbage is a versatile vegetable that can be prepared and used in various ways. It is commonly used in salads, coleslaw, sauerkraut, stir-fries, soups, stews, and as a filling in dishes such as cabbage rolls (Rombauer et al. 2019). Its adaptability in different cuisines makes it a staple in many traditional dishes across the world (Surya and Lee 2022). Historically, cabbage has been a crucial vegetable for European populations due to its availability, ease of cultivation, and ability to be preserved through fermentation and storage for the winter months (Dixon 2007). *Brassica* is one of the most important vegetables cultivated in Romania and is well known for its diversity and culinary properties, and for its adaptability to various environmental conditions (Bute et al. 2021). According to FAO Statistic, in our country, the total production of cabbage in 2021 was 548640 tons harvested from an area of 19470 ha (FAO 2023).

B. oleracea, includes various cultivars like cabbage, broccoli, cauliflower, kale, and Brussels sprouts (Cai 2023). These plants are susceptible to several pests and diseases that can affect their growth and yield. Implementing effective pest and disease management strategies is crucial to ensure healthy and productive *Brassica* crops (Ortega-Ramos et al. 2022; Zheng et al. 2020). Some common management practices are: crop rotation (Gupta and Kumar 2020); sanitation (Devi n.d.; Ortega-Ramos et al. 2022); biological control (Semerenko and Bushneva 2022); cultural practices (Kaur 2020); integrated pest management (IPM) (Ortega-Ramos et al. 2022; Stankevych et al. 2019); integrated avirulence management (IAM) (Aubertot et al. 2006); disease-resistant varieties (Islam, Hossain, and Islam 2021); fungicides (Brandt et al. 2007; Zahid et al. 2022); insecticides (Mpumi, R. Machunda, et al. 2020); soil health (Farjana, Islam, and Haque 2019); water management (Bute et al. 2021); quarantine (Rubel et al. 2019). By combining these management practices, farmers can effectively reduce the impact of pests and diseases on *Brassica* crops while promoting sustainable and environmentally friendly agricultural practices (Greer et al. 2023; Gupta and Kumar 2020). As agriculture continues to evolve and face new challenges, the future perspectives for pest and disease management in *Brassica* are likely to be influenced by advancements in technology, changes in agricultural practices, and a greater focus on sustainability (Greer et al. 2023).

The main reasons for low productivity of *B. oleracea* in Romania, can be attributed to several factors depending on the specific region and farming practices. To address the low productivity, farmers and agricultural stakeholders should focus on IPM strategies, disease-resistant varieties, proper soil management, and efficient water use. Implementing best agricultural practices and adopting appropriate technology can significantly improve productivity and overall crop health. Additionally, providing farmers with access to training and resources can help enhance their understanding of improved cultivation methods and contribute to increased productivity and profitability.

The paper aims to provide a comprehensive and forward-looking perspective on how pest and disease management in brassica crops can be improved to ensure food security, enhance agricultural productivity, and promote sustainable farming practices. By identifying future directions and potential solutions, the paper seeks to contribute to the advancement of knowledge and best practices in this critical aspect of *Brassica* cultivation.

MATERIAL AND METHODS

The primary objective of this systematic literature review is to explore the future perspectives for pest and disease management in brassica crops. A comprehensive search was conducted to identify relevant studies on pest and disease management in *Brassica* crops. Academic databases such as PubMed, Scopus, Web of Science, and Google Scholar were utilized. The search terms include variations of "brassica", "pest management," "disease management," "future perspectives," and related keywords.

Inclusion Criteria:

- Studies focusing on pest and disease management in brassica crops.
- Studies published in the English language.
- Studies available from the year 2000 to the present

Exclusion Criteria:

- Studies not directly related to pest and disease management in brassica crops.
- Studies published in languages other than English.
- Studies published before the year 2000.

The initial screening involves reviewing titles and abstracts of the retrieved articles to identify potentially relevant studies. Full-text articles of the selected studies were then reviewed to ensure they meet the inclusion criteria. A structured data extraction form has been developed to extract relevant information from each selected study. The data extracted included the author(s), publication year, study location, brassica species, pest and disease management strategies, and main findings. The quality assessment considers study design, sample size, data analysis methods, and reporting transparency. Thematic analysis was be conducted to identify common themes and trends in pest and disease management strategies for brassica crops. Based on the synthesized findings, potential future perspectives for pest and disease management in brassica crops were identified and discussed. Emphasis was placed on innovative and sustainable approaches. The limitations of this systematic literature review are recognized, including any potential bias resulting from the study selection process or the exclusion of studies written in other languages than English.

RESULTS AND DISCUSSIONS

This systematic literature review was conducted to explore future perspectives for pest and disease management in brassica crops. A rigorous search process identified 300 relevant papers, and through careful screening and evaluation, 81 papers (Table 1.) were selected for data extraction. These selected studies provided valuable insights into pest and disease management strategies for *Brassica* crops. In this section, we summarize key findings, identify common themes and trends, and highlight potential future directions in brassica pest and disease management.

The geographical distribution of *Brassica* species (Table 1.) and the pests/diseases affecting them is diverse. Reflecting the global significance of these crops, studies from Romania primarily focused on *B. oleracea* and reported the presence of various pests and diseases, including *Pieris brassicae*, *Pythium debaryanum*, *Peronospora brassicae*, *Mamestra brassicae*, *Delia brassicae*, *Phyllotreta spp.*, *Brevicoryne brassicae*, and snails (Cuc et al. 2007; Horga et al. 2023; Iabloncik et al. 2022; Iosob et al. 2020; Iosob, Cristea, and Bute 2022). In other European countries, scientific studies highlighted concerns related to pests such as *Pieris spp.*, *Phyllotreta spp.* and aphids (Depalo et al. 2017; Macioszek et al. 2020; Stankevych et al. 2019). Also, *B. oleracea* culture and *B. napus* faces *Plasmodiophora brassicae* and *Xanthomonas campestris pv. campestris* (Diederichsen, Frauen, and Ludwig-Müller 2014; Ragasová et al. 2020). The UK reported pests like *Psylliodes chrysocephala*, *Ceutorhynchus pallidactylus*, *Meligethes aeneus*, *Dasineura brassicae*, and various diseases, including *Rhizoctonia solani* in *Brassica oleracea*, and *Ceutorhynchus assimilis* in *B. napus* and *B. rapa* (Barari et al. 2005; Cook et al. 2006; Ferguson et al. 2003). In Asia *B. oleracea* is susceptible to *Fusarium equiseti*, *Pythium ultimum*, and *Xanthomonas campestris*. Various *Brassica* crops in Asia are attacked by aphids and white cabbage caterpillars. In Democratic People's Republic of Korea (DPRK), both *B. oleracea* and *B. campestris* are affected by *Plutella xylostella* and *Pieris rapae* (Afroz et al. 2021; Akram et al. 2019; Furlong et al. 2008; Furlong, Zu-Hua, et al. 2004; Grzywacz et al. 2010; Kianmatee and Ranamukhaarachchi 2007; Lu et al. 2021; Shaw et al. 2021; Srinivasan 2012; Srinivasan et al. 2019). In India, *Brassica* species (*oleracea*, *rapa*, *juncea*) contend with *Alternaria brassicicola, Peronospora parasitica, Sclerotinia sclerotiorum*, aphids, painted bugs, flea beetles, and more (Bhattacharya et al. 2014; Lal et al. 2020; Meena et al. 2004; Reddy and Guerrero 2000; Sharma et al. 2006, 2017; Shekhawat et al. 2012; Yadav et al. 2019). *B. oleracea* from Africa faces numerous pests, including *Plutella xylostella*, *Brevicoryne brassicae*, *Hellula undalis*, *Bemisia tabaci*, and *Trichoplusia ni*, resulting in leaf damage and reduced crop quality (Baidoo, Mochiah, and Apusiga 2012; Fening et al. 2013; Getnet and Raja 2013; Mpumi, R. S. Machunda, et al. 2020). In Tanzania, *B. oleracea* is affected by *Xanthomonas campestris*, causing black rot (Jensen et al. 2005). In Latin America, encompassing Mexico, Chile, and the Caribbean, *B. napus* and cruciferous vegetables encounter *Plasmodiophora brassicae*, causing clubroot disease and root deformities (Botero et al. 2019). North and

Central America face issues as well. In the USA, *B. rapa* is susceptible to soil nematodes, reducing root health and nutrient uptake (Matute 2013). Canada reports *Plasmodiophora brassicae* affecting *B. rapa* subsp. *chinensis* and *B. oleracea* var. *alboglabra*, causing clubroot disease and root deformities (McDonald, Kornatowska, and McKeown 2004). Oceania, specifically New Zealand, reports a variety of pests affecting spring- and autumn-sown seed and forage *Brassica* crops, including slugs, *Plutella xylostella*, *Pieris brassicae*, aphids, Nysius, springtails, and leaf miner, all of which damage plants and reduce yields (Horrocks, Horne, and Davidson 2018). Additionally, Australia faces *Bemisia tabaci*, *Hellula hydralis*, *H. undalis*, *Crocidolomia pavonana*, and *Plutella xylostella* in *Brassica* species, resulting in leaf damage and yield reduction (Furlong, Shi, et al. 2004; Walsh and Furlong 2008). Globally, *Brassica* crops face Turnip mosaic virus (TuMV) (Li et al. 2019), causing mosaic symptoms and potentially reducing marketability. Furthermore, they contend with *Plutella xylostella* and other key *Lepidoptera*, aphids, and secondary pests, lead to leaf damage and yield reduction (Grzywacz et al. 2010; Simon et al. 2014).

Pests like *Plutella xylostella*, *Brevicoryne brassicae*, *Mamestra brassicae*, and *Phyllotreta atra* can cause significant economic losses in *Brassica* culture. Management strategie for these pests are essential for safeguarding agricultural productivity and the livelihoods of farmers (Amer et al. 2009; Ndang'ang'a, Njoroge, and Vickery 2013; Parajuli and Paudel 2019; Reddy 2017; Santolamazza-Carbone et al. 2016; Sunanda, Jeyakumar, and Jacob 2014). Pathogens such as *Plasmodiophora brassicae, Alternaria brassicicola*, *A. brassicae*, *A. japonica* and *Xanthomonas campestris* can also lead to severe crop losses (Madloo et al. 2017; Michereff et al. 2012; Ragasová et al. 2020; Vásconez et al. 2020; Wang et al. 2019).

The data presented in table 1. reveals a diverse range of strategies for managing pests and diseases. These include cultural practices (Baysal-Gurel, Gardener, and Miller 2012), biological control methods (Botero et al. 2019), chemical interventions (Iabloncik et al. 2022), host resistance breeding (Ahuja, Rohloff, and Bones 2011; Degrave et al. 2021), IPM approaches (Grzywacz et al. 2010; Reddy 2011, 2017). The use of trap crops, such as turnip rape (*B. rapa*), and biological control agents like Baculoviruses, entomopathogenic fungi, and natural enemies, emerges as sustainable alternatives to chemical pesticides (Barari et al. 2005; Saeed, Shoukat, and Zafar 2017; Srinivasan et al. 2019; Waiganjo et al. 2011). The Starlight cultivar's ability to repel pests and the potential of turnip rape as a trap crop highlight the importance of plant selection in pest management (Cook et al. 2006). While synthetic insecticides remain a common pest management strategy, the data highlights challenges associated with their use, such as the development of resistance and concerns about environmental pollution. This underscores the need for alternative and integrated approaches. IPM strategies, combining multiple treatments, have shown effective results in mitigating biotic stresses in brassica crops. These strategies typically include biopesticides, natural enemies, cultural practices, and resistant varieties. Several studies emphasize the effectiveness of IPM approaches, often combining biological control agents like *Bacillus thuringiensis* with other strategies such as parasitoids (Cobblah et al. 2012) and sex pheromones (Srinivasan 2012). IPM can lead to better pest management while minimizing environmental impacts. Crop rotation with non-hosts (Hwang et al. 2014), intercropping with specific pest-repellent plants like sacred basil (Kianmatee and Ranamukhaarachchi 2007), and companion planting strategies are mentioned as effective ways to reduce pest populations and improve yield quality while promoting sustainable practices (Baidoo et al. 2012; Larkin 2013). Also, crop rotation and the use of resistant varieties are essential components of disease management, particularly for diseases like clubroot and black rot (Afrin et al. 2018; Dakouri et al. 2018; Wang et al. 2019). Identifying resistant cultivars and understanding their genetic basis are key for long-term control. Breeding for resistance to specific pests and diseases, such as clubroot and black rot, is a critical component of long-term pest and disease management (Ding et al. 2019; Mei et al. 2013; Rimmer 2006). The identification of resistance-related genes and marker-assisted selection are valuable tools in this regard. Genetically engineered *Brassica* crops and MS-engineered *Plutella xylostella* males demonstrate the potential of biotechnological solutions in pest control. These approaches can be part of a broader pest management strategy (Harvey-Samuel et al. 2015).

Adapting disease management strategies to different climatic conditions, as mentioned in the context of tropical climates, is essential for successful brassica cultivation (Simon et al. 2014). The influence of climate factors on pest populations, as observed in some studies, underscores the importance of adaptive pest management strategies under changing climatic conditions (Botero et al. 2019). Several studies emphasize the importance of reducing synthetic pesticide use to minimize environmental impacts and preserve natural enemy populations (Furlong, Zu-Hua, et al. 2004; Sarfraz, Dosdall, and Keddie 2006). Natural enemies, such as parasitoids and predatory arthropods, play a vital role in integrated pest management (Furlong et al. 2008; Srinivasan et al. 2019).

Their presence can reduce the need for chemical pesticides and promote sustainable pest control. Strategies like vermicompost application and green manures contribute to improved soil health and reduced pest infestations (Arancon, Galvis, and

Edwards 2005; Larkin 2013). The role of green manures in suppressing soilborne diseases highlights the importance of soil health in overall disease management strategies. Also, some studies highlight the significance of genomic analysis, transcriptomics, and genetic mapping in understanding host-pathogen interactions and identifying resistance genes (Marcroft et al. 2012; Sun et al. 2021; Wu et al. 2023; Zhang and Fernando 2017). Exploring plant-insect interactions, such as camalexin production and *Arabidopsis* microarrays, provides valuable insights into the mechanisms underlying pest resistance in brassica crops (Ahuja et al. 2011). This knowledge can make breeding efforts to develop pest-resistant varieties. In addition, continuous monitoring of pest and disease incidence is crucial for timely intervention and effective management (Lal et al. 2020). Pest and disease management strategies not only affect crop health but also impact economic returns for farmers. Effective strategies can lead to higher profits.

Based on the synthesized findings, several future perspectives for pest and disease management in *Brassica* crops emerge:

- Continued research into the optimization of biological control agents, such as parasitoids and entomopathogenic fungi, can lead to more effective and sustainable pest management solutions.
- Further exploration of resistance genes and molecular breeding techniques can expedite the development of *Brassica* varieties with durable resistance to common pests and diseases.
- The use of genetically engineered crops and innovative technologies, such as CRISPR-Cas9, holds potential for precise and targeted pest and disease control in *Brassica* crops.
- With changing climatic conditions, research into pest and disease management strategies that are adaptable to varying environmental factors is crucial.
- Promoting the adoption of eco-friendly practices, reducing reliance on synthetic pesticides, and encouraging IPM strategies are essential for sustainable *Brassica* production.
- Collaboration among researchers, policymakers, and agricultural communities on a global scale can facilitate the sharing of best practices and the adoption of innovative pest and disease management solutions.

CONCLUSION

Cabbage, a highly nutritious and culturally significant vegetable, faces a diverse range of pests and diseases globally, including *Plutella xylostella, Brevicoryne brassicae, Mamestra brassicae*, and various pathogens. These biotic stresses can cause substantial economic losses and yield reductions, highlighting the need for effective pest and disease management strategies.

Pest and disease management strategies for *Brassica* crops vary widely, encompassing cultural practices, biological control, chemical interventions, host resistance breeding, and integrated pest management. IPM approaches, combining multiple treatments, have demonstrated effectiveness in mitigating biotic stresses while minimizing environmental impacts. Sustainable alternatives to chemical pesticides, such as trap crops and natural enemies, show promise in reducing pest populations.

Future perspectives in pest and disease management for *Brassica* crops include optimizing biological control agents, exploring resistance genes and molecular breeding techniques, leveraging genetically engineered crops and innovative technologies like CRISPR-Cas9, adapting strategies to changing climatic conditions, promoting eco-friendly practices, and fostering global collaboration among researchers, policymakers, and agricultural communities.

These approaches aim to enhance agricultural productivity, ensure food security, and promote sustainable farming practices in the *Brassica* cultivation sector.

ABSTRACT

In this review, potential strategies for minimizing pest and disease challenges associated with *Brassica* crops are explored and discussed. Through a systematic literature review, we analyze the different methods and approaches used for pest and disease management.

Key findings highlight promising approaches to sustainable pest management, including the use of biological control agents and environmentally friendly insecticides.

We also discuss the importance of crop rotation, variety selection, and integrated pest management practices in reducing the impact of pests and diseases on *Brassica*.

It was concluded that the future perspectives are critical to their long-term health and productivity. This review provides valuable insights for researchers, farmers, and government agencies seeking innovative approaches to improve pest and disease management in *Brassica* crops.

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Table 1. Pest and disease management strategies for *Brassica* crops

Nr. crt	Author(s) and publication year	Study location	Brassica species	Pest/Disease sp.	Pests and Disease management strategies	Main findings
1	Abloncik A. R. et al., 2022	Romania	*Brassica oleracea*	*Pieris brassicae*	Chemical (deltamethrin, cyantranilyprol) and biological (*Bacillus thuringiensis*) insecticides tested for *Pieris brassicae* control.	Biological insecticide Bactospeine DF effectively controlled *Pieris brassicae* larvae initially, while chemical insecticides Benevia and Decis Expert provided sustained protection.
2	Afrin K. S. et al., 2018	Not specified	*Brassica oleracea*	*Xanthomonas campestris pv. campestris* (Xcc)	Screening cabbage inbred lines for resistance to black rot (Xcc) through bioassays and molecular markers.	Identified cabbage lines with race-specific resistance to different Xcc races; identified polymorphic molecular markers for resistance, paving the way for developing resistant cabbage cultivars.
3	Afroz T. et al., 2021	South Korea	*Brassica oleracea* var. capitate	*Fusarium equiseti*	Identification of the causal agent, *Fusarium equiseti*, and confirmation through molecular and pathogenicity testing.	First report of Fusarium wilt caused by *Fusarium equiseti* on cabbage in Korea, posing a threat to cabbage production, requiring effective disease management strategies.
4	Ahuja I. et al., 2011	Not mentioned	Brassica crops (not specified)	Insect pests attacking brassicas	The chemical ecology of wild *Brassica* germplasm holds promise for managing insect pests using genetic and breeding methods.	Camalexin: a potential Arabidopsis insecticide, Arabidopsis microarrays in *Brassica* studies, and exploring plant-insect interactions.
5	Akram W. et al., 2019	China	*Brassica oleracea var. alboglabra*	*Pythium ultimum*	The study reports on *Pythium* stem rot disease in *Brassica oleracea var. alboglabra*. Disease incidence increased with rainfall. The pathogen was identified using molecular and morphological methods. Timely measures are needed to manage this economically important disease, especially during rainy seasons.	The study identifies *Pythium ultimum* as the causal agent of stem rot disease in *Brassica oleracea var. alboglabra* in China, emphasizing the economic significance of managing this disease due to the plant's importance in the region.
6	Arancon, N. Q. et al. 2005	Not mentioned	*Brassica oleracea*	Aphids, mealy bugs, cabbage white caterpillars	Vermicompost substitutions reduced pest attacks and damage, possibly due to altered plant nutrition.	Vermicompost substitutions suppressed insect pest attacks, possibly through improved plant resistance linked to altered nutrient availability.
7	Aubertot J. N. et al., 2006	Not specified	*Brassica napus*	Phoma stem canker caused by *Leptosphaeria maculans*	Integrated Avirulence Management (IAM) combining cultural, physical, biological, or chemical control methods to limit pathogen population size and enhance resistance durability.	IAM can enhance the durability of specific resistances in the oilseed rape/*Leptosphaeria maculans* pathosystem.
8	Baidoo, P. K. and Mochiah, M. B., 2016	Africa	*Brassica oleracea*	*Plutella xylostella*, *Brevicoryne brassicae*, *Hellula undalis*, *Trichoplusia ni*	Evaluation of garlic and hot pepper extracts compared to chemical insecticide (Attack®)	Garlic and hot pepper extracts showed effective pest control comparable to chemical insecticide, with lower cost of application.
9	Baidoo, P. K., et al., 2012	Not mentioned	*Brassica sp.*	*Bemisia tabaci*, *Hellula undalis*, *Brevicoryne brassicae*, *Plutella xylostella*	Onion intercropping reduces *Bemisia tabaci*, *Hellula undalis*, and *Brevicoryne brassicae* infestation in cabbage.	Intercropping cabbage with onion effectively reduces specific pest populations, but not *Plutella xylostella* on cabbage.
10	Barari H. et al., 2005	United Kingdom (UK)	*Brassica napus*, *Brassica rapa*	*Psylliodes chrysocephala*, *Ceutorhynchus pallidactylus*	Turnip rape as a trap crop reduced *P. chrysocephala* infestation in oilseed rape, and insecticide treatment had little effect on pest or parasitoid incidence.	*Tersilochus microgaster* is reported for the first time in the UK and may serve as a larval parasitoid for *P. chrysocephala*. Integrated pest management implications are discussed.

11	Baysal-Gurel F. et al., 2012	USA	Mention of various vegetable crops, including brassica crops, susceptible to soilborne diseases.	Various soilborne pathogens, including fungal, bacterial, and nematode species.	The paper work outlines several strategies for managing soilborne diseases in organic vegetable production, including disease diagnosis and assessment, seed selection and storage, variety selection, organic matter amendments, sanitation, soil solarization, anaerobic soil disinfestation, crop rotation, and intercropping. It also mentions the use of biopesticides and microbial inoculants.	The paper work provides an overview of various strategies and methods for managing soilborne diseases in organic vegetable production. These strategies encompass cultural practices, crop selection, sanitation, and the use of organic-approved products to control diseases caused by a wide range of soilborne pathogens.
12	Bhattacharya I. et al., 2014	India	*Brassica oleracea, Brassica rapa, Brassica juncea*	*Plasmodiophora brassicae*	Soil amendments, cultural practices, bait cropping with resistant, susceptible, and non-brassicas, plant products, biocontrol agents	Clubroot caused by *Plasmodiophora brassicae* is present in India and requires various management strategies including soil amendments, cultural practices, and biocontrol agents.
13	Botero A. et al., 2019	Latin America (Mexico to Chile, including the Caribbean)	*Brassica napus*, cruciferous vegetables (cabbage, cauliflower, broccoli, Brussels sprouts)	*Plasmodiophora brassicae*	Adaptation of disease management strategies from temperate climates to tropical climates, including liming, biological control, and genetic resistance. Novel strategies like crop rotation with aromatic plant species and the use of biological control.	Latin America faces unique challenges with clubroot due to its climate and soil conditions. Research focuses on adapting management strategies from temperate regions and includes novel approaches. Further research is needed due to the region's distinct characteristics.
14	Brandt S. A. et al., 2007	Canada	*Brassica napus*	*Sclerotinia sclerotiorum*	Fungicide application	Hybrid canola (HYB) outperformed open-pollinated canola (OP) in terms of biomass and seed yield. Seeding rate and fertilizer influenced yield, with the best results seen when both inputs were high. Protein content was influenced by seeding rate and fertilizer, while oil content was affected by fertilizer levels. Net returns were highest for the HYB cultivar.
15	Budge G. E. et al., 2009	United Kingdom (UK)	*Brassica oleracea*	*Rhizoctonia solani*	Investigated the origin of *Rhizoctonia solani* infection in *Brassica oleracea* crops in the UK.	*R. solani* was associated with *Brassica oleracea* crops in the field rather than during propagation. Phylogenetic studies suggested the isolates were pathogenic on *Brassica spp.* Many isolates were found in symptomless plant material.
16	Cobblah M. A. et al., 2012	Ghana	*Brassica oleracea var. capitata*	*Plutella xylostella*	*Cotesia plutellae* is a key parasitoid of *Plutella xylostella*, suitable for integrated pest management in Ghana.	*Cotesia plutellae*, a major parasitoid, effectively controlled *Plutella xylostella* populations with density dependence.
17	Cook S.M. et al., 2006	United Kingdom (UK)	*Brassica napus, Brassica rapa*	*Meligethes aeneus* and *Ceutorhynchus assimilis*	Low proportions of alkenyl glucosinolates in the leaves for oilseed rape cultivar (Starlight) and utilization of turnip rape (*Brassica rapa*) as a trap crop.	Starlight cultivar repels pests; turnip rape shows potential as trap crop. Further optimization needed.
18	Cuc G. et al., 2007	Romania	*Brassica oleracea*	*Pythium debaryanum*, *Peronospora brassicae*, *Mamestra brassicae*, *Delia brassicae*, *Phyllotreta spp.*, *Brevicoryne brassicae*, snails	Integrated approach with irrigation, mulching, and pesticides effectively controlled pests, diseases, and weeds.	Successful management of cabbage pests, diseases, and weeds using irrigation, mulching, and targeted pesticides.

19	Dakouri A. et al., 2018	Not specified	*Brassica oleracea*	*Plasmodiophora brassicae*	Identification of the clubroot resistance gene Rcr7 in cabbage cultivar 'Tekila' through genetic mapping using bulked segregant RNA sequencing. The study used the percentage of polymorphic variants (PPV) to map the gene's location on chromosome C7. Kompetitive Allele-Specific PCR confirmed the gene's association with SNPs in the region. Seven genes encoding disease resistance proteins were found in the target region, but only two were expressed. 'Kilaherb' was identified as carrying SNP alleles associated with Rcr7, providing resistance to pathotypes 3 and 5X.	Rcr7, a clubroot resistance gene in cabbage, was identified and mapped to chromosome C7. 'Kilaherb' was found to carry SNP alleles associated with Rcr7, providing resistance to multiple pathotypes of Plasmodiophora brassicae.
20	Degrave A. et al., 2021	Not specified	*Brassica oleracea*	*Leptosphaeria maculans*	Identification of a new avirulence gene (AvrLm14) in *Leptosphaeria maculans* and its interaction with a potential resistance gene (Rlm14) in American broccoli genotypes.	Discovered a new resistance source for stem canker disease in American broccoli genotypes, potentially effective against French *L. maculans* isolates. Identified and characterized the avirulence gene AvrLm14 and its interaction with the Rlm14 resistance gene.
21	Depalo L. et al., 2017	Italy, Denmark, Germany, Slovenia	*Brassica oleracea*	*Pieris spp.* and Aphids	Living mulch (LM) systems positively impact arthropod biodiversity and reduce canopy pest infestations.	Living mulch (LM) technique enhances arthropod diversity and minimally affects canopy pest density in cabbage crops.
22	Diederichsen E. et al., 2014	Germany	*Brassica napus*	*Plasmodiophora brassicae*	Research on host resistance, genetic basis, integrated control, physiological alterations in the host. Clubroot-resistant cultivar 'Mendel' a milestone. Agronomical approaches like calcium cyanamide and integrated pest management strategies.	Clubroot research in Germany addresses various aspects, including resistance, genetics, and integrated control. The resistant oilseed rape cultivar 'Mendel' is significant in clubroot management.
23	Ding Y. et al., 2019	Not specified	*Brassica oleracea*	*Sclerotinia sclerotiorum*	The study investigates the transcriptome changes in *Brassica oleracea* in response to *Sclerotinia sclerotiorum* infection. It highlights the host's (*Brassica oleracea*) strategies for resisting the pathogen, including the repression of virulence genes in the pathogen, induction of receptors in the host, activation of Ca2+ signaling, suppression of pathogen oxalic acid generation, and inhibition of cell wall degradation.	The resistant *Brassica oleracea* exhibits strong responses against *Sclerotinia sclerotiorum* during early infection, deploying various strategies to suppress pathogen establishment and infection.
24	Fening K. O. et al., 2013	Ghana	*Brassica oleracea* var. capitata	*Brevicoryne brassicae* and *Plutella xylostella*	Homemade garlic and pepper extracts showed comparable efficacy to the synthetic insecticide ATTACK® against cabbage pests.	Garlic and pepper extracts have potential as affordable plant protection products for cabbage pests, suitable for smallholder farms and organic vegetable production systems.
25	Ferguson A. W. et al., 2003	United Kingdom (UK)	*Brassica napus*	*Ceutorhynchus assimilis*, *Ceutorhynchus pallidactylus*, *Meligethes aeneus*, *Dasineura brassicae*, *Psylliodes chrysocephala*	Potential for spatially targeted insecticide applications in oilseed rape for optimized pest control.	Complex patterns of insect density within the crop offer potential for spatially targeted applications and pest control strategies.

26	Furlong M. J. et al., 2008	Democratic People's Republic of Korea (DPRK)	*Brassica oleracea* and *Brassica campestris*	*Plutella xylostella* and *Pieris rapae*	Pests are managed by scheduled broad-spectrum insecticides, and limited natural enemy utilization.	An IPM strategy with Bt significantly increased crop yields, but natural enemy impact remained relatively low. Recommendations for improved biological control and pest management were given.
27	Gadi V P Reddy, 2011	Not mentioned	*Brassica spp*.	Insect pests on cabbage	Integrated Pest Management (IPM) using neem (Aza-Direct) and DiPel (*Bacillus thuringiensis*).	IPM with neem and DiPel reduced pest populations and damage, resulting in better cabbage yield and economic returns compared to standard chemical practices.
28	Getnet, M., and Raja, N., 2013	Gondar, Ethiopia	*Brassica oleracea*	*Brevicoryne brassicae*	Vermicompost application enhances cabbage growth and reduces aphid infestation.	Vermicompost significantly promotes cabbage growth and suppresses aphid infestation, offering sustainable pest management.
29	Grzywacz D. et al., 2010	Global	Brassica crops (not specified)	*Plutella xylostella* and other key *Lepidoptera*, aphids, and secondary pests	Deployment of insect-resistant brassicas within an IPM context is crucial for sustainable pest management.	Introducing durable insect-resistant brassicas can promote agricultural productivity without heavy reliance on synthetic insecticides.
30	Grzywacz D. et al., 2010	South Asia and Africa	Brassica crops (not specified)	*Plutella xylostella*	Synthetic insecticides are the most common control strategy, but they face challenges.	Biologically-based efforts with parasitoids have limited impact; IPM technology and DBM-resistant brassicas are crucial.
31	Harvey-Samuel T. et al., 2015	Not mentioned	Not mentioned	*Plutella xylostella*	Genetically engineered male-selecting (MS) *P. xylostella* can effectively suppress pest populations and complement Bt crops for resistance management.	MS-engineered *P. xylostella* males rapidly reduced and eliminated pest populations, supporting their potential as an effective pest control option.
32	Horga V-A. et al., 2023	Romania	*Brassica rapa*	Pest complex affecting rapeseed	Comparison of conventional and reduced tillage systems for rapeseed pest control and production.	Reduced tillage system resulted in lower pest incidence and increased rapeseed production compared to conventional tillage.
33	Horrocks A. et al., 2018	New Zealand	Spring- and autumn-sown seed and forage brassica crops	Various pests including slugs, *Plutella xylostella*, *Pieris brassicae*, aphids, Nysius, springtails, leaf miner	Integrated Pest Management (IPM) significantly reduced insecticide use, maintained yields, and increased IPM adoption.	IPM adoption led to reduced insecticide use, maintained yields, and widespread industry change towards IPM practices.
34	Hwang S.-F. et al., 2014	Western Canada	*Brassica napus*	*Plasmodiophora brassicae*	Soil liming, crop rotation with non-hosts and bait crops, adjusting sowing dates, farm equipment sanitization, deploying resistant cultivars	Genetic resistance is a practical option for clubroot management in canola, but stewardship, crop rotation, and cultural practices are needed to maintain its effectiveness.
35	Iosob G-A. et al., 2020	Romania	*Brassica oleracea var. capitata*	*Mamestra brassicae*, *Discestra trifolii*, *Pieris brassicae*, *Plutella xylostella*	*Trichogramma evanescens* and parasitoid *Hymenoptera* play important roles in biological pest control in cabbage.	*Trichogramma evanescens* preferentially parasitizes harmful lepidopteran pests in cabbage, suggesting potential for biological control.
36	Iosob G-A. et al., 2022	Romania	*Brassica oleracea*	*Meligethes aeneus*, *Ceutorhynchus pallidactylus*, *Ceutorhynchus assimilis*, *Brevicoryne brassicae*	Emphasis on pest species affecting seed cabbage, potential resistance to Deltamethrin, and future focus on sustainable pest control.	Pest species including rape beetle, weevils, and aphids affect seed cabbage; some potential resistance observed; studyes are need for sustainable pest management.
37	Jensen B.D. et al., 2005	Tanzania	*Brassica oleracea*	*Xanthomonas campestris pv. campestris*	Field evaluation of cabbage genotypes for resistance to black rot through artificial inoculation with Xcc race 1.	Some cabbage genotypes, including Portuguese and pointed cabbages, exhibited partial resistance to black rot. Hybrid cultivars like T-689 F1 and Badger I-16 showed high levels of resistance. Disease severity on leaves during the growing season correlated with head resistance, making it an efficient method for selecting resistant cultivars.

38	Kianmatee, S., and Ranamukhaarachchi , S. L. 2007	Thailand	*Brassica oleracea*	*Phyllotreta sinuata*, *Hellula undalis*, *Spodoptera litura*	Intercropping with specific pest repellent plants like sacred basil reduces pest populations and damage, increasing yield quality.	Intercropping Chinese kale with sacred basil reduces pest damage and enhances yield quality.
39	Lal J. et al., 2020	India	*Brassica oleracea* var. capitata	Aphids, painted bug, flea beetle, *Plutella xylostella*, *Spodoptera litura*	Monitoring seasonal incidence of major insect pests on cabbage.	Abundant infestations of aphids, painted bug, flea beetle, and diamondback moth occurred during specific seasons. Temperature, relative humidity, and sunshine correlated with pest populations. Tobacco caterpillar appeared only in 2016-17.
40	Larkin R. P., 2013	Not specified	Brassica and related crops (specific species not mentioned)	Various plant pathogens including *Rhizoctonia*, *Verticillium*, *Sderotinia*, *Phythophthora, Pythium, Aphanomyces*, and *Macrophomina*	Green manures, particularly *Brassica* green manures, for disease suppression.	Green manures, especially from Brassica crops, can effectively suppress various plant pathogens, making them a valuable component of integrated disease management for sustainable crop production.
41	Li G., et al., 2019	Worldwide, especially Europe, Asia, and North America	Various economically important brassica crops including cabbage, Chinese cabbage, oilseed rape, and mustard	Turnip mosaic virus (TuMV)	Seeking host resistance through the study of TuMV resistance genes, which can facilitate resistance breeding for brassica crops.	Extensive research has identified TuMV resistance genes in brassica crops, providing potential for effective disease control.
42	Lu L. et al., 2021	Korea and Russia	*Brassica oleracea*	*Xanthomonas campestris pv. campestris*	Identifying cabbage lines with resistance to black rot disease using pathogenicity assays. Studying early defense mechanisms.	Cabbage line BR155 exhibited higher expression of defense-related genes and antioxidant activity, suggesting a role of ROS scavenging systems in cabbage's early defense against black rot disease. This provides insights for cabbage resistance research.
43	Macioszek V. K. et al., 2020	Poland	*Brassica oleracea* var. capitata f. alba	*Alternaria brassicicola*	Understanding the complex interaction between *Brassica oleracea* and *Alternaria brassicicola* at molecular, ultrastructural, and physiological levels.	Black spot disease severely damages chloroplasts and negatively impacts photosynthesis in white cabbage. The early downregulation of photosynthesis suggests a host defense strategy or fungal virulence factors.
44	Madloo P. Et al., 2018	Not specified	*Brassica oleracea*	*Xanthomonas campestris pv. campestris* (Xcc)	Studied the interaction between kale genotypes with varying glucosinolate (GSL) content and Xcc to assess the impact of GSL content on disease severity.	Increasing glucosinolate content in kale doesn't consistently enhance plant resistance to Xcc; indolic GSLs had a clear effect, while aliphatic GSLs did not.
45	Marcroft S. J. et al., 2012	Not specified	*Brassica napus*	*Leptosphaeria maculans*	Rotation of canola cultivars with different complements of blackleg resistance genes to minimize disease pressure and manipulate fungal populations.	Rotating canola cultivars with different resistance gene complements reduces disease severity and helps prevent resistance breakdown in the blackleg pathogen. This strategy can be a valuable tool for canola growers and potential for other crops.
46	Marghub A. et al., 2009	Pakistan	*Brassica napus*	*Brevicoryne brassicae* and *Lipahis eyrsimi*	Application of insecticides is necessary to manage aphids and prevent economic damage	Canola varieties tested lacked resistance against aphids; insecticide application is crucial.
47	Matute M. M., 2013	USA	*Brassica rapa*	Soil nematodes	Investigating nematode populations and effects of temperature and pH on Brassica rapa.	Soil nematode populations fluctuated with pH and temperature, potentially posing a threat to Brassica rapa production.
48	McDonald M. R. et al., 2004	Canada	*Brassica rapa* subsp. chinensis, *Brassica oleracea* var. alboglabra	*Plasmodiophora brassicae*	Evaluated calcium cyanamide (Perlka) and lime for clubroot management on organic soils. Varying application rates and timings.	Perlka reduced clubroot incidence more effectively than lime in trials, especially when applied before seeding. Crop selection and seeding timing can also help manage clubroot.

49	Meena P. D. et al., 2004	India	*Brassica juncea*	*Alternaria brassicae*	Fungicides (mancozeb, carbendazim), Allium sativum (garlic) bulb extract, Acacia nilotica leaf extract, Trichoderma viride isolate GR, application at specific plant ages (45 and 75 days after sowing)	Mancozeb and garlic bulb extract effectively reduced disease severity, with 75 days after sowing identified as the most critical age for disease development. Trichoderma viride GR isolate performed well.
50	Mei J. et al., 2013	Not specified	Wild *Brassica oleracea*	*Sclerotinia sclerotiorum*	Mapping quantitative trait loci (QTL) for *Sclerotinia* resistance from wild *B. oleracea* to improve resistance in rapeseed (*Brassica napus*).	Wild *B. oleracea* accessions possessed higher levels of *Sclerotinia* resistance than recognized partially resistant accessions of *B. napus*. Multiple QTL for resistance were identified, particularly on chromosome C09. Flowering time was negatively correlated with susceptibility, indicating potential pleiotropic effects.
51	Michael J. Furlong, 2004	Australia	*Brassica sp.*	*Plutella xylostella*	Endemic natural enemies have the greatest impact in IPM cabbage fields, reducing insecticide inputs and maintaining yield.	Three larval parasitoids and one pupal parasitoid, along with predatory arthropods, contribute to *P. xylostella* mortality. IPM promotes higher natural enemy abundance and diversity.
52	MichereffI S. J. et al., 2012	Brazil	*Brassica oleracea*	*Alternaria brassicicola* and *A. brassicae*	Surveyed the occurrence and prevalence of *Alternaria* species causing leaf spots in various brassica crops in Pernambuco.	*A. brassicae* was found in all Chinese cabbage fields, while *A. brassicicola* was found in all fields of cabbage, cauliflower, and broccoli. *A. brassicicola* was more prevalent overall. The study suggests host preference within *Alternaria* species, critical for managing leaf spots in *Brassicaceae* species.
53	Mpumi N. et al., 2020	Tanzania	*Brassica oleracea*	*Plutella xylostella*, *Helula undalis, Pieris brassicae, Brevycoryne brassicae, Trichoplusia ni, Myzus persicae*	Over-reliance on synthetic pesticides for cabbage pest control intensifies environmental pollution	Recommends reducing synthetic pesticide use, promoting botanical alternatives, and ecological research for sustainable cabbage pest management in Africa.
54	Ndang'ang'a, P. K., et al, 2013	Not mentioned	*Brassica sp.*	Aphids, thrips, invertebrate pests	Birds contribute to pest control in kale fields, reducing invertebrate pest load.	Foraging birds in dry seasons reduce aphid and thrips abundance, lowering leaf damage in kale.
55	Parajuli S. and Paudel S. , 2019	Nepal	*Brassica oleracea*	*Plutella xylostella*	Integrated pest management with botanical, biological, cultural methods, and resistant varieties is effective.	Excessive chemical insecticide use causes heavy cabbage yield loss, emphasizing the need for eco-friendly integrated pest management practices.
56	Ragasová L. et al., 2020	Czech Republic	*Brassica oleracea var. capitata*	*Xanthomonas campestris pv. campestris*	Storage conditions affect the bacterial spectrum of cabbage heads. *Bacillus* species were the most frequent bacteria, and the presence of *Bacillus* subtilis group increased after storage, potentially due to antagonistic interactions with *Pseudomonas sp.*	Xcc infection severity increased after four months of storage. *Bacillus* species were the most common bacteria. The presence of *Bacillus* subtilis group increased significantly after storage, possibly due to antagonistic interactions.
57	Reddy G. V. P., 2017	Not mentioned	*Brassica napus, Brassica juncea, Camelina sp., Crambe sp.*	*Plutella xylostella*, *Phyllotreta spp.*, cabbage seed pod weevil, swede midge, tarnished plant bug, aphids, grasshopper	This book provides comprehensive insights into integrated pest management strategies for *Brassica* oilseed crops.	Canola and other *Brassica* oilseed crops face significant pest challenges, warranting effective integrated pest management approaches.
58	Reddy G.VP , 2011	Guam	Hybrid Cabbage (K-K Cross)	*Spodoptera litura*, *Pieris brassicae*	IPM with neem and DiPel proved cost-effective in managing pests on cabbage crops.	An IPM regime with neem and DiPel is a competitive option for cabbage pest management.
59	Reddy, G. V. P., and Guerrero, A., 2000	Karnataka State, India	*Brassica oleracea* var capitata	*Plutella xylostella*	IPM program with *Cotesia plutellae*, *Chrysoperla carnea*, nimbecidine, *Bacillus thuringiensis*, and phosalone reduced DBM damage and cost effectively.	IPM reduced pest populations, damage, and input costs, leading to higher gross and net profit.
60	Rimmer S. R., 2006	Canada, Australia, Europe	*Brassica napus*	*Leptosphaeria maculans*	Primarily reliant on resistant cultivars, with concerns about increasing pathotype diversity and resistance breakdown.	The study focuses on resistance associated with the A genome and long-term resistance achievement.

61	Saeed M. et al., 2017	Pakistan	*Brassica oleracea*	Army worm, vegetable weevil, *B. oleracea* butterfly, *Plutella xylostella*, aphid (and various natural enemies)	IPM and reduced risk pesticides are effective for managing cabbage pests while preserving natural enemies.	IPM and reduced risk pesticides reduce pest populations and promote natural enemy activity, benefiting cabbage production.
62	Sarfraz M . et al., 2006	Not mentioned	Cruciferous crops, transgenic crucifers	*Plutella xylostella*	Integrated strategies, including Bt-engineered plants and host plant manipulation, are effective against diamondback moth.	Bt-engineered crucifers have potential for diamondback moth control, but societal and environmental concerns remain.
63	Santolamazza-Carbone S. et al.., 2016	Not mentioned	*Brassica oleracea var. acephala*	*Mamestra brassicae*, *Pieris rapae*	Investigating effects of glucosinolate concentrations on larval development and feeding behavior	Glucosinolates in *Brassica oleracea var. acephala* affect larval development and feeding preferences of both generalist and specialist lepidopteran pests.
64	Sharma B.B. et al., 2017	New Delhi and Mohali, India	*Brassica oleracea*, *Brassica carinata*	*Xanthomonas campestris pv. campestris* (Xcc)	Introgression of black rot resistance from *Brassica carinata* to cauliflower through interspecific hybridization and backcrossing, confirmed using molecular markers.	Successful development of black rot-resistant interspecific hybrids and backcross progeny, paving the way for durable resistance in cauliflower and cabbage.
65	Sharma P. et al., 2006	India	*Brassica oleracea* var. *botrytis* subvar *cauliflora*	*Alternaria brassicicola*, *Peronospora parasitica*, *Sclerotinia sclerotiorum*	Biological, chemical, and integrated disease management (IDM) modules	IDM was the most effective in disease control and resulted in the highest yield increase for cauliflower.
66	ShawR. K. et al., 2021	China	*Brassica oleracea var. botrytis*	*Hyaloperonospora parasitica*	Developing resistant cauliflower varieties through molecular breeding strategies, including QTL mapping and marker-assisted selection.	Molecular breeding techniques, such as QTL mapping and marker-assisted selection, offer promising avenues to develop durable downy mildew-resistant cauliflower varieties.
67	Shekhawat K. et al., 2012	India	*Brassica napus*	Insect pests attacking brassicas	Proper management practices, including nutrient management and integrated pest control, can enhance rapeseed-mustard productivity.	The paper highlights advances in management techniques to meet oilseed demand and increase production.
68	Simon S. et al., 2014	France and Benin	*Brassica oleracea* var. capitata	Aphids, *Spodoptera littoralis*	Insect net physical control system improved cabbage yields with suitable mesh sizes and removal frequencies.	Fine mesh had a significant impact on microclimate but didn't improve netting efficacy against pests. Net removal 3 days/week was a good trade-off for efficacy and microclimate.
69	Srinivasan R. et al., 2017	Taiwan, Vietnam, Syria, Samoa, Asia	*Brassica rapa* var. pekinensis, *B. rapa* var. chinensis, *B. rapa* var. parachinensis, *B. oleracea* var. alboglabra	*Plutella xylostella*, *Crocidolomia pavonana*, *Pieris rapae*, *Myzus persicae*, *Lipaphis erysimi*, *Brevicoryne brassicae*, *Phyllotreta spp.*	Integrated pest management approaches are essential to reduce pesticide misuse in brassica crops.	Effective bio-control agents and bio-pesticides can enhance pest management and safer brassica production in Asia.
70	Srinivasan R. et al., 2019	Asia and Africa	Brassica crops (not specified)	Pod borer on food legumes and unspecified pests of vegetable legumes and brassicas	The use of baculoviruses and entomopathogenic fungi	Use of biopesticide formulations based on baculoviruses and/or entomopathogenic fungi have great potential to reduce the use of chemical pesticides.
71	Srinivasan R., 2012	Tropical Asia	Brassica crops (not specified)	Insect pests attacking brassicas	IPM with biopesticides, natural enemies, and sex pheromones	Biopesticides like *Bacillus thuringiensis* enhance IPM with parasitoids and sex pheromones for effective pest management.
72	Stankevych S.V. et al., 2019	Ukraine	*Brassica napus*	*Phyllotreta spp.*	Presowing toxicity of rapeseeds reduces undulating flea beetle population below economic threshold levels.	Spring rape yield and seed weight are influenced by undulating flea beetle damage and fertilizers. Seed treatment affects germination negatively.

73	Sun Q. et al., 2020	China	*Brassica oleracea*	*Xanthomonas campestris* pv. *campestris*	Transcriptomic analysis to understand early defense responses in Xcc-resistant and Xcc-susceptible *Brassica oleracea* lines.	Identification of upregulated and downregulated genes, enhanced glucosinolate pathways, ROS scavenging, hormonal responses, and photosynthetic energy metabolism in response to Xcc infection, aiding in understanding host responses and disease prevention strategies.
74	Sunanda B.S. et al., 2014	Not specified	*Brassica oleracea* var. *capitata*	*Plutella xylostella*	Evaluating the efficacy of indigenous Steinernema carpocapsae nematodes at different dosages for controlling diamondback moth in cabbage, both in laboratory and field conditions.	In laboratory conditions, 100% mortality of diamondback moth larvae was achieved with a dosage of 1000 IJs/petri plate within 72 hours. In field conditions, the highest mortality (60%) of diamondback moth was recorded at 30 lakh IJs/plot with WDG formulation and liquid paraffin 1% after 7 days of application.
75	Vásconez R. D. A. et al., 2020	Not specified	*Brassica oleracea* var. *italica*	*Alternaria japonica*	Development of biopreparations containing *Bacillus megaterium* to control *Alternaria japonica* in broccoli.	*Bacillus megaterium* biopreparation effectively reduced *Alternaria japonica* disease index in broccoli leaves to less than 15.6%, comparable to chemical treatment.
76	Waiganjo, M. M et al., 2011	Kenya	*Brassica oleracea* var. *capitata*	*Plutella xylostella*, *Myzus persicae* and *Lipaphis erysimi*	Use of an entomopathogenic fungus (*Beauveria bassiana*) and neem oil extracts (Azadiractin) against diamondback moth and aphids in cabbage.	Bio-pesticides reduced pests, increased cabbage weight, and natural enemies played a vital role in integrated pest management in Kenya.
77	Walsh B., Furlong M. J. , 2008	Australia	Brassica crops (not specified)	*Bemisia tabaci, Hellula hydralis, H. undalis, Crocidolomia pavonana, Plutella xylostella*	Imidacloprid seedling root treatment coupled with foliar sprays effectively manages early-season *Brassica* pests.	Imidacloprid treatment of seedling roots reduces *Hellula spp.* and *B. tabaci* infestations, supporting successful integrated pest management against diamondback moth.
78	Wang S. et al., 2019	China	*Brassica oleracea* var. *capitata*	*Plasmodiophora brassicae*	Identifying molecular mechanisms of clubroot resistance in cabbage. Transcriptomic analysis revealed candidate resistance-related genes.	1057 and 4741 differentially expressed genes (DEGs) were found in clubroot-resistant and susceptible cabbage lines, respectively. DEGs were associated with metabolism, transport, signal transduction, and defense. 165 resistance-related DEGs were identified, potentially contributing to clubroot resistance.
79	Wu Y. et al., 2023	China	*Brassica oleracea* var. *capitata*	*Hyaloperonospora parasitica*	Genomic analysis to understand the infection mechanisms of *Hyaloperonospora parasitica* in cabbage.	The study presents the whole-genome sequence of *H. parasitica* isolate BJ2020, which causes downy mildew in cabbage, providing insights into the pathogenic mechanisms and foundations for further research.
80	Yadav M.S. et al., 2019	India	*Brassica juncea*	Aphid, white rust, Alternaria blight, Sclerotinia rot	Integrated Pest Management strategy with various treatments showed effective mitigation of biotic stresses in *Brassica juncea*.	Seed treatment with *Trichoderma harzianum* and fresh garlic bulb extract provided the highest incremental benefit cost ratio (IBCR) for mustard crop in India.
81	Zhang X. and Dilantha Fernando W. G. , 2017	Canada	*Brassica napus*	*Leptosphaeria maculans*	Reliance on resistant canola varieties, but *L. maculans* populations evolve rapidly, necessitating diversified and efficient resistance genes and frequent monitoring.	The introduction of blackleg resistance gene Rlm3 into Canadian canola varieties provided good resistance until the early 2000s when resistance breakdown occurred due to evolving fungal populations. Canola breeding programs need to develop diversified and efficient resistance genes, and monitoring is crucial.

REFERENCES

1. AFRIN, KHANDKER SHAZIA, MD ABDUR RAHIM, JONG-IN PARK, SATHISHKUMAR NATARAJAN, MEHEDE HASSAN RUBEL, HOY-TAEK KIM, AND ILL-SUP NOU. 2018. "Screening of Cabbage (Brassica Oleracea L.) Germplasm for Resistance to Black Rot." *Plant Breeding and Biotechnology* 6(1):30–43.
2. AFROZ, TANIA, SAMNYU JEE, HYO-WON CHOI, JI HYEON KIM, AWRARIS DERBIE ASSEFA, MD AKTARUZZAMAN, BUM-SOO HAHN, AND HO-SUN LEE. 2021. "First Report of Fusarium Wilt Caused by Fusarium Equiseti on Cabbage (Brassica Oleracea Var. Capitate) in Korea." *Plant Disease* 105(4):1198–1198.
3. AHUJA, ISHITA, JENS ROHLOFF, AND ATLE MAGNAR BONES. 2011. "Defence Mechanisms of Brassicaceae: Implications for Plant-Insect Interactions and Potential for Integrated Pest Management." *Sustainable Agriculture Volume 2* 623–70.
4. AKRAM, WAHEED, GUIHUA LI, JUXIAN GUO, AQEEL AHMAD, WENLONG LUO, DASEN XIE, AND QING WANG. 2019. "Pythium Ultimum Causing Black Stem Rot of Brassica Oleracea Var. Alboglabra in China." *Plant Disease* 103(10):2698–2698.
5. AMER, MARGHUB, MUHAMMAD ASLAM, MUHAMMAD RAZAQ, AND MUHAMMAD AFZAL. 2009. "Lack of Plant Resistance against Aphids, as Indicated by Their Seasonal Abundance in Canola, Brassica Napus (L.) in Southern Punjab, Pakistan." *Pakistan J. Bot* 41(3):1043–51.
6. ARANCON, NORMAN Q., PAOLA A. GALVIS, AND CLIVE A. EDWARDS. 2005. "Suppression of Insect Pest Populations and Damage to Plants by Vermicomposts." *Bioresource Technology* 96(10):1137–42.
7. AUBERTOT, J. N., J. S. WEST, L. BOUSSET-VASLIN, M. U. SALAM, M. J. BARBETTI, AND A. J. DIGGLE. 2006. "Improved Resistance Management for Durable Disease Control: A Case Study of Phoma Stem Canker of Oilseed Rape (Brassica Napus)." Pp. 91–106 in *Sustainable strategies for managing Brassica napus (oilseed rape) resistance to Leptosphaeria maculans (phoma stem canker): Under the aegis of a European-Australian workshop held at INRA, Versailles, France, in association with the EU SECURE project (QLK5-CT-2002-01813)*, edited by B. D. L. Fitt, N. Evans, B. J. Howlett, and B. M. Cooke. Dordrecht: Springer Netherlands.
8. BAIDOO, PK, MB MOCHIAH, AND K. APUSIGA. 2012. "Onion as a Pest Control Intercrop in Organic Cabbage (Brassica Oleracea) Production System in Ghana." *Sustainable Agriculture Research* 1(526-2016–37755).
9. BARARI, HASSAN, SAMANTHA M. COOK, SUZANNE J. CLARK, AND INGRID H. WILLIAMS. 2005. "Effect of a Turnip Rape (Brassica Rapa) Trap Crop on Stem-Mining Pests and Their Parasitoids in Winter Oilseed Rape (Brassica Napus)." *BioControl* 50:69–86.
10. BAYSAL-GUREL, FULYA, BRIAN MCSPADDEN GARDENER, AND SALLY A. MILLER. 2012. "Soil Borne Disease Management in Organic Vegetable Production." *Organic Agri*.
11. BHATTACHARYA, INDRABRATA, SUBRATA DUTTA, SUBHASIS MONDAL, AND BHOLANATH MONDAL. 2014. "Clubroot Disease on Brassica Crops in India." *Canadian Journal of Plant Pathology* 36(sup1):154–60.
12. BOTERO, ANDREA, CELSA GARCÍA, BRUCE D. GOSSEN, STEPHEN E. STRELKOV, CHRISTOPHER D. TODD, PETA C. BONHAM□SMITH, AND EDEL PÉREZ□LÓPEZ. 2019. "Clubroot Disease in Latin America: Distribution and Management Strategies." *Plant Pathology* 68(5):827–33.
13. BRANDT, SA, SS MALHI, D. ULRICH, GP LAFOND, HR KUTCHER, AND AM JOHNSTON. 2007. "Seeding Rate, Fertilizer Level and Disease Management Effects on Hybrid versus Open Pollinated Canola (Brassica Napus L.)." *Canadian Journal of Plant Science* 87(2):255–66.
14. BUTE, ALEXANDRU, GABRIEL-ALIN IOSOB, ANDREEA ANTAL-TREMURICI, CREOLA BREZEANU, PETRE MARIAN BREZEANU, TINA OANA CRISTEA, AND SILVICA AMBARUŞ. 2021. "The Most Suitable Irrigation Methods in Cabbage Crops (Brassica Oleracea L. Var. Capitata): A Review." *Scientific Papers. Series B. Horticulture* 65(1).
15. CAI, CHENGCHENG. 2023. "Unlocking the Secrets of Brassica Oleracea Crops: A Genomic Journey."
16. CANDOLLE, ALPHONSE. 2021. *Origin of Cultivated Plants*. Litres.
17. COBBLAH, MILLICENT A., K. AFREH-NUAMAH, D. WILSON, AND MY OSAE. 2012. "Parasitism of Plutella Xylostella (L.)(Lepidoptera: Plutellidae) Populations on Cabbage Brassica Oleracea Var. Capitata (L.) by Cotesia Plutellae (Kurdjumov)(Hymenoptera: Braconidae) in Ghana." *West African Journal of Applied Ecology* 20(1):37–45.
18. COOK, SM, LE SMART, JL MARTIN, DA MURRAY, NP WATTS, AND IH WILLIAMS. 2006. "Exploitation of Host Plant Preferences in Pest Management Strategies for Oilseed Rape

(Brassica Napus).” *Entomologia Experimentalis et Applicata* 119(3):221–29.
19. CUC, GABRIE, OANA POP, DANIELA POP, ION OLTEAN, AND SIMONA OROS. 2007. “Research Concerning the Integrated Control of Diseases Pests and Weeds in Cabbage Crop.” *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Agriculture* 271–76.
20. DAKOURI, ABDULSALAM, XINGGUO ZHANG, GARY PENG, KEVIN C. FALK, BRUCE D. GOSSEN, STEPHEN E. STRELKOV, AND FENGQUN YU. 2018. “Analysis of Genome-Wide Variants through Bulked Segregant RNA Sequencing Reveals a Major Gene for Resistance to Plasmodiophora Brassicae in Brassica Oleracea.” *Scientific Reports* 8(1):17657.
21. DEGRAVE, ALEXANDRE, MARINE WAGNER, PIERRE GEORGE, LAURENT COUDARD, XAVIER PINOCHET, MAGALI ERMEL, ELISE J. GAY, ISABELLE FUDAL, ONESIMO MORENO□RICO, AND THIERRY ROUXEL. 2021. “A New Avirulence Gene of Leptosphaeria Maculans, AvrLm14, Identifies a Resistance Source in American Broccoli (Brassica Oleracea) Genotypes.” *Molecular Plant Pathology* 22(12):1599–1612.
22. DEPALO, LAURA, GIOVANNI BURGIO, P. VON FRAGSTEIN, HL KRISTENSEN, M. BAVEC, M. ROBAČER, G. CAMPANELLI, AND S. CANALI. 2017. “Impact of Living Mulch on Arthropod Fauna: Analysis of Pest and Beneficial Dynamics on Organic Cauliflower (Brassica Oleracea L. Var. Botrytis) in Different European Scenarios.” *Renewable Agriculture and Food Systems* 32(3):240–47.
23. DEVI, SUSMITA JHA1AND M. RANJANA. n.d. “Integrated Disease Managment in Vegetable Seed Production.”
24. DIEDERICHSEN, ELKE, MARTIN FRAUEN, AND JUTTA LUDWIG-MÜLLER. 2014. “Clubroot Disease Management Challenges from a German Perspective.” *Canadian Journal of Plant Pathology* 36(sup1):85–98.
25. DING, YIJUAN, JIAQIN MEI, YARU CHAI, YANG YU, CHAOGUO SHAO, QINAN WU, JOSEPH ONWUSEMU DISI, YUHUA LI, HUAFANG WAN, AND WEI QIAN. 2019. “Simultaneous Transcriptome Analysis of Host and Pathogen Highlights the Interaction between Brassica Oleracea and Sclerotinia Sclerotiorum.” *Phytopathology* 109(4):542–50.
26. DIXON, GEOFFREY R. 2007. *Vegetable Brassicas and Related Crucifers*. CABI.
27. EBABHI, ABOSEDE, AND RAIMOT ADEBAYO. 2022. “Nutritional Values of Vegetables.” in *Vegetable Crops-Health Benefits and Cultivation*. IntechOpen London.
28. FAO, Statistic. 2023. “Crops and Livestock Products.” Retrieved July 27, 2023 (https://www.fao.org/faostat/en/#data/QCL).
29. FARJANA, SALEHA, MD ASHRAFUL ISLAM, AND TAMANNA HAQUE. 2019. “Effects of Organic and Inorganic Fertilizers, and Mulching on Growth and Yield of Cabbage (Brassica Oleracea Var. Capitata L.).” *Journal of Horticulture and Postharvest Research* 2(2):95–104.
30. FENING, KO, BW AMOABENG, I. ADAMA, MB MOCHIAH, H. BRAIMAH, M. OWUSU-AKYAW, E. NARVEH, AND SO EKYEM. 2013. “Sustainable Management of Two Key Pests of Cabbage, Brassica Oleracea Var. Capitata L.(Brassicaceae), Using Homemade Extracts from Garlic and Hot Pepper.” *Organic Agriculture* 3:163–73.
31. FERGUSON, ANDREW W., ZDISŁAW KLUKOWSKI, BARBARA WALCZAK, SUZANNE J. CLARK, MOIRA A. MUGGLESTONE, JOE N. PERRY, AND INGRID H. WILLIAMS. 2003. “Spatial Distribution of Pest Insects in Oilseed Rape: Implications for Integrated Pest Management.” *Agriculture, Ecosystems & Environment* 95(2–3):509–21.
32. FURLONG, MICHAEL J., KIM HAK JU, PAK WI SU, JO KWANG CHOL, RI CHANG IL, AND MYRON P. ZALUCKI. 2008. “Integration of Endemic Natural Enemies and Bacillus Thuringiensis to Manage Insect Pests of Brassica Crops in North Korea.” *Agriculture, Ecosystems & Environment* 125(1–4):223–38.
33. FURLONG, MICHAEL J., ZU□HUA SHI, SHU□SHENG LIU, AND MYRON P. ZALUCKI. 2004. “Evaluation of the Impact of Natural Enemies on Plutella Xylostella L.(Lepidoptera: Yponomeutidae) Populations on Commercial Brassica Farms.” *Agricultural and Forest Entomology* 6(4):311–22.
34. FURLONG, MICHAEL J., SHI ZU-HUA, LIU YIN-QUAN, GUO SHI-JIAN, LU YAO-BIN, LIU SHU-SHENG, AND MYRON P. ZALUCKI. 2004. “Experimental Analysis of the Influence of Pest Management Practice on the Efficacy of an Endemic Arthropod Natural Enemy Complex of the Diamondback Moth.” *Journal of Economic Entomology* 97(6):1814–27.
35. GETNET, MULUSEW, AND NAGAPPAN RAJA. 2013. “Impact of Vermicompost on Growth and Development of Cabbage, Brassica Oleracea Linn. and Their Sucking Pest, Brevicoryne Brassicae Linn.(Homoptera: Aphididae).” *Research Journal of Environmental and Earth Sciences* 5(3):104–12.
36. GREER, SHANNON F., ARTHY SURENDRAN, MURRAY GRANT, AND ROBERT LILLYWHITE. 2023. “The Current

Status, Challenges, and Future Perspectives for Managing Diseases of Brassicas." *Frontiers in Microbiology* 14.
37. GRZYWACZ, D., A. ROSSBACH, ABDUL RAUF, DA RUSSELL, R. SRINIVASAN, AND AM SHELTON. 2010. "Current Control Methods for Diamondback Moth and Other Brassica Insect Pests and the Prospects for Improved Management with Lepidopteran-Resistant Bt Vegetable Brassicas in Asia and Africa." *Crop Protection* 29(1):68–79.
38. GUPTA, ANUJA, AND RAVINDRA KUMAR. 2020. "Management of Seed-Borne Diseases: An Integrated Approach." *Seed-Borne Diseases of Agricultural Crops: Detection, Diagnosis & Management* 717–45.
39. HARVEY-SAMUEL, TIM, NEIL I. MORRISON, ADAM S. WALKER, THEA MARUBBI, JU YAO, HILDA L. COLLINS, KEVIN GORMAN, TG DAVIES, NINA ALPHEY, AND SIMON WARNER. 2015. "Pest Control and Resistance Management through Release of Insects Carrying a Male-Selecting Transgene." *BMC Biology* 13(1):1–15.
40. HORGA, VASILE-ADRIAN, VLĂDUȚ-IONUȚ ȘTER, DAN-LAURENȚIU SUCIU, IONUȚ-BOGDAN HULUJAN, TEODORA FLORIAN, AND TEODOR RUSU. 2023. "Influence of Soil Tillage Systems on Rapeseed Production Parameters and on the Numerical Density of Pest Complex." *Bulletin of the University of Agricultural Sciences & Veterinary Medicine Cluj-Napoca. Agriculture* 80(1).
41. HORROCKS, ABIE, PAUL A. HORNE, AND MELANIE M. DAVIDSON. 2018. "Demonstrating an Integrated Pest Management Strategy in Forage-and Seed-Brassica Crops Using a Collaborative Approach." *New Zealand Plant Protection* 71:112–20.
42. HWANG, S. F., RJ HOWARD, SE STRELKOV, BD GOSSEN, AND G. PENG. 2014. "Management of Clubroot (Plasmodiophora Brassicae) on Canola (Brassica Napus) in Western Canada." *Canadian Journal of Plant Pathology* 36(sup1):49–65.
43. IABLONCIK, ANAMARIA ROBERTA, ADINA IENOVAN, MONICA OLIMPIA SPERLEA, A. CĂRĂBEȚ, IOANA GROZEA, AND RAMONA ŞTEF. 2022. "The Influence of Chemical and Biological Substances in Reducing Pieris Brassicae Population in Brassica Oleracea Culture." *Research Journal of Agricultural Science* 54(3).
44. IOSOB, GABRIEL-ALIN, MARIA CĂLIN, TINA OANA CRISTEA, SILVICA AMBARUŞ, CREOLA BREZEANU, PETRE MARIAN BREZEANU, MARIA PRISECARU, ALEXANDRU BUTE, MARIANA CALARA, AND ANDREEA ANTAL TREMURICI. 2020. "Parasitic Hymenoptera and Their influence on the number of lepidoptera pests for *Brassica oleracae* L. var capitata from the experimental field of the Vegetable Research and Development Station Bacău." *Scientific Studies & Research. Series Biology/Studii Si Cercetari Stiintifice. Seria Biologie* 29(2).
45. IOSOB, GABRIEL-ALIN, TINA OANA CRISTEA, AND ALEXANDRU BUTE. 2022. "Observations on arthropods from the seed cabbage crop during the growing season and under the climatic conditions in Bacau." *Scientific Studies & Research. Series Biology/Studii Si Cercetari Stiintifice. Seria Biologie* 31(1).
46. ISLAM, AKM AMINUL, MOHAMMAD ANWAR HOSSAIN, AND AKM MOMINUL ISLAM. 2021. *Brassica Breeding and Biotechnology*. BoD–Books on Demand.
47. JENSEN, BRITA DAHL, SAID MS MASSOMO, IGNAS S. SWAI, JOHN HOCKENHULL, AND SVEN BODE ANDERSEN. 2005. "Field Evaluation for Resistance to the Black Rot Pathogen Xanthomonas Campestris Pv. Campestris in Cabbage (Brassica Oleracea)." *European Journal of Plant Pathology* 113:297–308.
48. KAUR, ARSHPREET. 2020. "Impact of Various Organic Manures on Yield, Yield Attributes and Economics of Cabbage (Brassica Oleracea Var. Capitata L.)." *Journal of Pharmacognosy and Phytochemistry* 9(2):1439–42.
49. KIANMATEE, SUPAWAN, AND SL RANAMUKHAARACHCHI. 2007. "Pest Repellent Plants for Management of Insect Pests of Chinese Kale, Brassica Oleracea L." *Int. J. Agric. Biol* 9:64–67.
50. KUMAR, DEEPAK, SATENDRA KUMAR, AND CHANDRA SHEKHAR. 2020. "Nutritional Components in Green Leafy Vegetables: A Review." *Journal of Pharmacognosy and Phytochemistry* 9(5):2498–2502.
51. LAL, JHUMAR, R. SWAMINATHAN, ASHOK KUMAR MEENA, AND RAJENDRA NAGAR. 2020. "Seasonal Incidence of Major Insect Pests of Cabbage, Brassica Oleracea Var. Capitata L." *Journal of Entomology and Zoology Studies* 8(3):387–91.
52. LARKIN, ROBERT P. 2013. "Green Manures and Plant Disease Management." *CABI Reviews* (2013):1–10.
53. LI, GUOLIANG, HONGHAO LV, SHUJIANG ZHANG, SHIFAN ZHANG, FEI LI, HUI ZHANG, WEI QIAN, ZHIYUAN FANG, AND RIFEI SUN. 2019. "TuMV Management for Brassica Crops through Host Resistance: Retrospect and Prospects." *Plant Pathology* 68(6):1035–44.

54. LU, LU, SOKRAT G. MONAKHOS, YONG PYO LIM, AND SO YOUNG YI. 2021. "Early Defense Mechanisms of Brassica Oleracea in Response to Attack by Xanthomonas Campestris Pv. Campestris." *Plants* 10(12):2705.
55. MACIOSZEK, VIOLETTA KATARZYNA, MAGDALENA GAPIŃSKA, AGNIESZKA ZMIENKO, MIROSŁAW SOBCZAK, ANDRZEJ SKOCZOWSKI, JAKUB OLIWA, AND ANDRZEJ KIEJSTUT KONONOWICZ. 2020. "Complexity of Brassica Oleracea–Alternaria Brassicicola Susceptible Interaction Reveals Downregulation of Photosynthesis at Ultrastructural, Transcriptional, and Physiological Levels." *Cells* 9(10):2329.
56. MADLOO, PARI, M. LEMA, M. FRANCISCO, AND P. SOENGAS. 2017. "Changes in Glucosinolates Content in Brassica Oleracea Modulate Disease Severity Caused by Xanthomonas Campestris Pv. Campestris." Pp. 75–80 in.
57. MARCROFT, SJ, AP VAN DE WOUW, PA SALISBURY, TD POTTER, AND BJ HOWLETT. 2012. "Effect of Rotation of Canola (Brassica Napus) Cultivars with Different Complements of Blackleg Resistance Genes on Disease Severity." *Plant Pathology* 61(5):934–44.
58. MATUTE, MARTIN MOLUWA. 2013. "Soil Nematodes of Brassica Rapa: Influence of Temperature and PH." *Advances in Natural Science* 6(4):20–26.
59. MCDONALD, MR, B. KORNATOWSKA, AND AW MCKEOWN. 2004. "Management of Clubroot of Asian Brassica Crops Grown on Organic Soils."
60. MEENA, PD, RL MEENA, C. CHATTOPADHYAY, AND ARVIND KUMAR. 2004. "Identification of Critical Stage for Disease Development and Biocontrol of Alternaria Blight of Indian Mustard (Brassica Juncea)." *Journal of Phytopathology* 152(4):204–9.
61. MEI, JIAQIN, YIJUAN DING, KUN LU, DAYONG WEI, YAO LIU, JOSEPH ONWUSEMU DISI, JIANA LI, LIEZHAO LIU, SHENGYI LIU, AND JOHN MCKAY. 2013. "Identification of Genomic Regions Involved in Resistance against Sclerotinia Sclerotiorum from Wild Brassica Oleracea." *Theoretical and Applied Genetics* 126:549–56.
62. MICHEREFF, SAMI J., MARISSÔNIA A. NORONHA, MARIA S. XAVIER FILHA, MARCOS PS CÂMARA, AND AILTON REIS. 2012. "Survey and Prevalence of Species Causing Alternaria Leaf Spots on Brassica Species in Pernambuco." *Horticultura Brasileira* 30:345–48.
63. MPUMI, NELSON, REVOCATUS MACHUNDA, KELVIN MTEI, AND PATRICK NDAKIDEMI. 2020. "Insecticidal Efficacy of Syzygium Aromaticum, Tephrosia Vogelii and Croton Dichogamus Extracts against Plutella Xylostella and Trichoplusia Ni on Brassica Oleracea Crop in Northern Tanzania."
64. MPUMI, NELSON, REVOCATUS S. MACHUNDA, KELVIN M. MTEI, AND PATRICK A. NDAKIDEMI. 2020. "Selected Insect Pests of Economic Importance to Brassica Oleracea, Their Control Strategies and the Potential Threat to Environmental Pollution in Africa." *Sustainability* 12(9):3824.
65. NDANG'ANG'A, PAUL KARIUKI, JOHN BM NJOROGE, AND JULIET VICKERY. 2013. "Quantifying the Contribution of Birds to the Control of Arthropod Pests on Kale, Brassica Oleracea Acephala, a Key Crop in East African Highland Farmland." *International Journal of Pest Management* 59(3):211–16.
66. ORTEGA□RAMOS, PATRICIA A., DUNCAN J. COSTON, GAËTAN SEIMANDI□CORDA, ALICE L. MAUCHLINE, AND SAMANTHA M. COOK. 2022. "Integrated Pest Management Strategies for Cabbage Stem Flea Beetle (Psylliodes Chrysocephala) in Oilseed Rape." *GCB Bioenergy* 14(3):267–86.
67. PARAJULI, SOVIT, AND SANDIP PAUDEL. 2019. "Eco-Friendly Management of Diamondback Moth (Plutella Xylostella L.) of Cabbage (Brassica Oleracea Var. Capitata) in Nepal." *International Journal of Applied Sciences and Biotechnology* 7(3):304–8.
68. RAGASOVÁ, LUCIA, ELIŠKA PEŇÁZOVÁ, FILIP GAZDÍK, JAKUB PEČENKA, JANA ČECHOVÁ, ROBERT POKLUDA, MIROSLAV BARÁNEK, DARIUSZ GRZEBELUS, AND ALEŠ EICHMEIER. 2020. "The Change of Bacterial Spectrum after Storage of X. Campestris Pv. Campestris Inoculated Cabbage Heads (Brassica Oleracea Var. Capitata L.)." *Agronomy* 10(3):443.
69. REDDY, GADI VP. 2011. "Comparative Effect of Integrated Pest Management and Farmers' Standard Pest Control Practice for Managing Insect Pests on Cabbage (Brassica Spp.)." *Pest Management Science* 67(8):980–85.
70. REDDY, GADI VP. 2017. *Integrated Management of Insect Pests on Canola and Other Brassica Oilseed Crops*. CABI.
71. REDDY, GVP, AND ANGEL GUERRERO. 2000. "Behavioral Responses of the Diamondback Moth, Plutella Xylostella, to Green Leaf Volatiles of Brassica o Leracea Subsp. c Apitata." *Journal of Agricultural and Food Chemistry* 48(12):6025–29.
72. RIMMER, S. ROGER. 2006. "Resistance Genes to Leptosphaeria Maculans in Brassica Napus." *Canadian Journal of Plant Pathology* 28(S1):S288–97.

73. ROMBAUER, IRMA S., MARION ROMBAUER BECKER, ETHAN BECKER, JOHN BECKER, AND MEGAN SCOTT. 2019. *Joy of Cooking: 2019 Edition Fully Revised and Updated*. Scribner.
74. RUBEL, MEHEDE HASSAN, SATHISHKUMAR NATARAJAN, UJJAL KUMAR NATH, MICHAEL IMMANUEL JESSE DENISON, JUNG HEE-JEONG, KIM HOY-TAEK, PARK JONG-IN, AND NOU ILL-SUP. 2019. "Development of a Marker for Detection of Xanthomonas Campestris Pv. Campestris Races 1 and 2 in Brassica Oleracea." *Horticulture, Environment, and Biotechnology* 60:511–17.
75. SAEED, MUHAMMAD, RANA FARTAB SHOUKAT, AND JUNAID ZAFAR. 2017. "Population Dynamics of Natural Enemies and Insect Pest in Different Brassica Oleracea (Cabbage) Growing Seasons with Different Production Systems." *J. Entomol. Zool. Stud* 5(6):1669–74.
76. SANTOLAMAZZA-CARBONE, SERENA, TAMARA SOTELO, PABLO VELASCO, AND MARÍA ELENA CARTEA. 2016. "Antibiotic Properties of the Glucosinolates of Brassica Oleracea Var. Acephala Similarly Affect Generalist and Specialist Larvae of Two Lepidopteran Pests." *Journal of Pest Science* 89:195–206.
77. SARFRAZ, M., LM DOSDALL, AND BA KEDDIE. 2006. "Diamondback Moth–Host Plant Interactions: Implications for Pest Management." *Crop Protection* 25(7):625–39.
78. SEMERENKO, SA, AND NA BUSHNEVA. 2022. "The Biological Control of Pests in Sowings of Spring Rapeseed Brassica Napus L." P. 012019 in Vol. 1045. IOP Publishing.
79. SHARMA, BRIJ B., PRITAM KALIA, DINESH SINGH, AND TILAK R. SHARMA. 2017. "Introgression of Black Rot Resistance from Brassica Carinata to Cauliflower (Brassica Oleracea Botrytis Group) through Embryo Rescue." *Frontiers in Plant Science* 8:1255.
80. SHARMA, PRATIBHA, SR SHARMA, SK SAIN, AND A. DHANDAPANI. 2006. "Integrated Management of Major Diseases of Cauliflower (Brassica Oleracea Var Botrytis Subvar Cauliflora)." *Indian Journal of Agricultural Sciences* 76(12):726.
81. SHAW, RANJAN K., YUSEN SHEN, ZHENQING ZHAO, XIAOGUANG SHENG, JIANSHENG WANG, HUIFANG YU, AND HONGHUI GU. 2021. "Molecular Breeding Strategy and Challenges towards Improvement of Downy Mildew Resistance in Cauliflower (Brassica Oleracea Var. Botrytis L.)." *Frontiers in Plant Science* 12:667757.
82. SHEKHAWAT, KAPILA, SS RATHORE, OP PREMI, BK KANDPAL, AND JS CHAUHAN. 2012. "Advances in Agronomic Management of Indian Mustard (Brassica Juncea (L.) Czernj. Cosson): An Overview." *International Journal of Agronomy* 2012.
83. SIDDEEG, AZHARI, MUHAMMAD AFZAAL, FARHAN SAEED, REHMAN ALI, YASIR ABBAS SHAH, UMBER SHEHZADI, HUDA ATEEQ, NUMRA WARIS, MUZZAMAL HUSSAIN, AND MUHAMMAD AHTISHAM RAZA. 2022. "Recent Updates and Perspectives of Fermented Healthy Super Food Sauerkraut: A Review." *International Journal of Food Properties* 25(1):2320–31.
84. SIMON, SERGE, F. ASSOGBA KOMLAN, L. ADJAÏTO, ARMEL MENSAH, HUBERT KACOU COFFI, MATHIEU NGOUAJIO, AND THIBAUD MARTIN. 2014. "Efficacy of Insect Nets for Cabbage Production and Pest Management Depending on the Net Removal Frequency and Microclimate." *International Journal of Pest Management* 60(3):208–16.
85. SRINIVASAN, R. 2012. "Integrating Biopesticides in Pest Management Strategies for Tropical Vegetable Production." *Journal of Biopesticides* 5.
86. SRINIVASAN, R., LIN, M. Y., HIEN, N. T. T., & HAI, V. M. .2017. Biological control in vegetable Brassica pest management in tropical Asia: where do we currently stand?. *In Proceedings of the 5th International Symposium on Biological Control of Arthropods*, Langkawi, Malaysia, September 11-15, 2017 (pp. 144-146). Wallingford UK: CABI.
87. SRINIVASAN, RAMASAMY, SUBRAMANIAN SEVGAN, SUNDAY EKESI, AND MANUELE TAMÒ. 2019. "Biopesticide Based Sustainable Pest Management for Safer Production of Vegetable Legumes and Brassicas in Asia and Africa." *Pest Management Science* 75(9):2446–54.
88. STANKEVYCH, SV, MD YEVTUSHENKO, VV VILNA, IV ZABRODINA, NV LUTYTSKA, YU O. NAKONECHNA, OA MOLCHANOVA, VO MELENTI, LV GOLOVAN, AND IV KLYMENKO. 2019. "Integrated Pest Management of Flea Beetles (Phyllotreta Spp.) in Spring Oilseed Rape (Brassica Napus L.)." *Ukrainian Journal of Ecology* 9(3):198–207.
89. SUN, QINGGUO, ENHUI ZHANG, YAPING LIU, ZHONGMIN XU, MAIXIA HUI, XINXIN ZHANG, AND MEIJIE CAI. 2021. "Transcriptome Analysis of Two Lines of Brassica Oleracea in Response to Early Infection with Xanthomonas Campestris Pv. Campestris." *Canadian Journal of Plant Pathology* 43(1):127–39.
90. SUNANDA, BS, P. JEYAKUMAR, AND VV JACOB. 2014. "Bioefficacy of Different Formulations of Entomopathogenic Nematode

Steinernema Carpocapsae against Diamond Back Moth (Plutella Xylostella) Infesting Cabbage (Brassica Oleracea Var. Capitata).” *Journal of Biopesticides* 7(2):210.
91. SURYA, REGGIE, AND ANNE GA-YEON LEE. 2022. “Exploring the Philosophical Values of Kimchi and Kimjang Culture.” *Journal of Ethnic Foods* 9(1):1–14.
92. VÁSCONEZ, RAMIRO DANIEL ACURIO, ESTEFANY MICHELLE TENORIO MOYA, LEIDY ANDRINA COLLAGUAZO YÉPEZ, VIVIANA PAMELA CHILUISA-UTRERAS, AND IVONNE DE LOS ÁNGELES VACA SUQUILLO. 2020. “Evaluation of Bacillus Megaterium Strain AB4 as a Potential Biocontrol Agent of Alternaria Japonica, a Mycopathogen of Brassica Oleracea Var. Italica.” *Biotechnology Reports* 26:e00454.
93. WAIGANJO, MM, CN WATURU, JM MUREITHI, J. MURIUKI, J. KAMAU, AND R. MUNENE. 2011. “Use of Entomopathogenic Fungi and Neem Bio-Pesticides for Brassica Pest Control and Conservation of Their Natural Enemies.” *East African Agricultural and Forestry Journal* 77(1 & 2).
94. WALSH, B., AND MJ FURLONG. 2008. “Imidacloprid Treatment of Seedling Roots as a Component of Integrated Pest Management in Brassica Crops.” China Agricultural Science and Technology Press.
95. WANG, SHENYUN, FANGWEI YU, WEI ZHANG, JUN TANG, JIANBIN LI, LI YU, HONG WANG, AND JIEZENG JIANG. 2019. “Comparative Transcriptomic Analysis Reveals Gene Expression Changes during Early Stages of Plasmodiophora Brassicae Infection in Cabbage (Brassica Oleracea Var. Capitata L.).” *Canadian Journal of Plant Pathology* 41(2):188–99.
96. WU, YUANKANG, BIN ZHANG, SHAOBO LIU, ZHIWEI ZHAO, WENJING REN, LI CHEN, LIMEI YANG, MU ZHUANG, HONGHAO LV, AND YONG WANG. 2023. “A Whole-Genome Assembly for Hyaloperonospora Parasitica, A Pathogen Causing Downy Mildew in Cabbage (Brassica Oleracea Var. Capitata L.).” *Journal of Fungi* 9(8):819.
97. YADAV, MS, S. GODIKA, DK YADAVA, N. AHMAD, N. MEHTA, K. BHATNAGAR, VK AGRAWAL, A. KUMAR, L. THOMAS, AND C. CHATTOPADHYAY. 2019. “Prioritizing Components of Package of Integrated Pest Management in Indian Mustard (Brassica Juncea) in India for Better Economic Benefit.” *Crop Protection* 120:21–29.
98. ZAHID, KHIZRA, AMER HABIB, SHAHBAZ MUSTAFA, AND WAQAS AHMAD KHAN. 2022. “Management of White Mold Disease of Cabbage (Brassica Oleracea Var. Capitata) through Different Plant Extracts and Chemicals.” *Plant Protection* 6(1):51–56.
99. ZHANG, XUEHUA, AND WG DILANTHA FERNANDO. 2017. “Insights into Fighting against Blackleg Disease of Brassica Napus in Canada.” *Crop and Pasture Science* 69(1):40–47.
100. ZHENG, XIAORONG, BIRGER KOOPMANN, BERND ULBER, AND ANDREAS VON TIEDEMANN. 2020. “A Global Survey on Diseases and Pests in Oilseed Rape—Current Challenges and Innovative Strategies of Control.” *Frontiers in Agronomy* 2:590908.

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