International Journal of Agriculture and Plant Science
www.agriculturejournal.in
Online ISSN: 2664-7664, Print ISSN: 2664-7656
Received: 17-03-2024, Accepted: 04-04-2024, Published: 26-04-2024
Volume 6, Issue 2, 2024, Page No. 27-28

Examining the genetic improvement of mustard for resistance to pests and diseases

Eleonora Di Cioppi [1] and Marco Maria [1]
[1] Department of Agricultural, Forest and Food Sciences, University of Turin, Grugliasco, Torino, Italy

Abstract
Mustard *(Brassica spp.*) is a significant crop due to its use as an oilseed worldwide and its culinary applications. However, its production is severely hampered by various pests and diseases, which can drastically reduce yield and quality. This review explores the genetic improvement of mustard plants for enhanced resistance to these threats, focusing on conventional breeding techniques, genetic engineering, and the integration of new biotechnological tools.

Keywords: Phenotypic, bioinformatics, environmental, breeding

Introduction

Mustard crops, primarily consisting of species such as *Brassica juncea*, *Brassica nigra*, and *Brassica hirta*, are cultivated globally for their seeds and leaves. Despite their economic importance, mustard plants are susceptible to a range of pests and diseases, including fungi, bacteria, viruses, and insects. The economic losses associated with these afflictions necessitate an ongoing search for resistant varieties. Enhancing resistance through genetic improvement is critical for sustainable mustard production.

Objective

The main objective of this review is to examining the Genetic Improvement of Mustard for Resistance to Pests and Diseases.

Conventional Breeding for Resistance

Conventional breeding has long been the backbone of agricultural crop improvement, with a focus on enhancing disease and pest resistance among mustard varieties. This method primarily involves the selection of plants that exhibit desired traits, such as resistance to specific pests or diseases, based on phenotypic evaluations under natural or artificially infested conditions. Once potential candidates are identified, they are cross-bred with high-yielding or otherwise advantageous varieties to combine traits in the offspring. This often requires several generations of backcrossing to achieve a commercially viable plant that expresses the desired traits robustly. Field testing and evaluation of these progeny across multiple growing seasons and varying environmental conditions is crucial to ensure the stability and effectiveness of the resistance traits. Successful varieties that pass these tests are then released for cultivation. Over the decades, several resistant mustard varieties have been developed through conventional breeding. These include varieties with resistance to common fungal diseases like white rust caused by *Albugo candida* and blackleg disease caused by *Leptosphaeria maculans*. There has also been significant progress in developing varieties resistant to insect pests such as the mustard aphid (*Lipaphis erysimi*), and efforts are ongoing to combat bacterial and viral diseases, although these are often more challenging due to the pathogens' complexity. Despite these achievements, conventional breeding is not without its limitations. It can be a slow process, often taking a decade or more to develop a new variety. This pace may not be sufficient to address rapidly evolving pest and disease threats. Moreover, reliance on a small gene pool can lead to genetic bottlenecks, reducing genetic diversity and potentially making the crop more susceptible to new diseases or environmental changes. Traits that are influenced by multiple genes, such as environmental stress tolerance or complex disease resistance, are particularly challenging to breed for using traditional methods.

Molecular Breeding and Genetic Engineering

Molecular breeding and genetic engineering represent advanced methodologies that have significantly impacted the development of pest and disease-resistant mustard varieties. Molecular breeding, especially marker-assisted selection (MAS), has revolutionized how breeders select for desired traits. By identifying specific DNA sequences linked to resistance traits, MAS allows for the accurate and efficient selection of plants even before they mature. This method is particularly useful in mustard breeding programs where resistance to diseases like white rust and blackleg disease can be traced to specific genetic markers, thereby speeding up the selection process and increasing breeding accuracy. Genetic engineering takes the potential of mustard improvement a step further by directly modifying the plant's genetic makeup. Through techniques like transgenic modification, genes that confer resistance to pests and diseases are introduced directly into the mustard genome. For instance, genes that produce proteins toxic to specific insects or enhance fungal resistance can be incorporated, providing a level of resistance that is difficult to achieve through conventional breeding alone. This method can also introduce novel traits such as herbicide resistance, which helps mustard plants thrive in various agricultural settings by simplifying weed management. Despite the promise of these technologies, they are not without challenges and controversies. The development and release of genetically modified (GM) mustard have been met with regulatory and public scrutiny. Concerns about potential environmental impacts, gene flow to wild relatives, and long-term health implications in humans have led to stringent regulatory processes that can delay or prevent the commercial release of GM mustard varieties. Additionally, while molecular breeding techniques like MAS do not involve direct genetic modification, they rely heavily on detailed genetic knowledge and resources, which can be costly and resource-intensive to develop.

Integration of Biotechnological Tools

The integration of biotechnological tools in mustard breeding has significantly advanced the ability to develop crop varieties that are resistant to pests and diseases. These tools include genomic selection, gene pyramiding, and the use of bioinformatics, each contributing uniquely to the enhancement of breeding programs. Genomic selection involves the use of whole-genome data to predict the breeding value of a plant even before testing it in the field. This approach allows breeders to select individuals with desirable traits more accurately and efficiently, significantly reducing the breeding cycle time. By evaluating the genetic potential of plants at a seedling stage, genomic selection facilitates the rapid advancement of generations, speeding up the development of new varieties with combined traits of high yield and resistance. Gene pyramiding is another crucial technique where multiple genes responsible for resistance to different diseases or pests are stacked into a single variety. This strategy enhances the durability of resistance traits, as it is less likely that a pest or pathogen will simultaneously overcome multiple resistance genes. For example, mustard varieties can be engineered to carry resistance genes for both fungal infections and insect attacks, ensuring broad-spectrum resilience that can stand up to varied agricultural threats. Bioinformatics plays a pivotal role in these processes by enabling the analysis and interpretation of large datasets generated through genomic studies. With the help of bioinformatics, breeders can identify genetic markers linked to desirable traits more quickly and understand the complex interactions between genes and environmental factors. This knowledge is crucial for designing breeding strategies that are both effective and adaptable to changing climatic conditions. The integration of these biotechnological tools has not only improved the efficiency and accuracy of breeding programs but also opened new possibilities for overcoming some of the traditional limitations of conventional breeding. By leveraging genomic data, computational power, and molecular biology techniques, breeders can now address the growing demands for food security and sustainable agricultural practices more effectively. As these technologies continue to evolve and become more accessible, their application in mustard breeding is expected to expand, leading to the development of varieties that are not only high-yielding but also robust against a range of biological stresses.

Conclusion

The journey of improving mustard's resistance to pests and diseases through breeding and biotechnology illustrates a dynamic field of agricultural science that marries traditional methods with cutting-edge technologies. While conventional breeding has laid a strong foundation, the incorporation of molecular breeding, genetic engineering, and other biotechnological tools has significantly accelerated the pace and precision of developing new mustard varieties. These advancements not only enhance the crop's resistance to various biotic stresses but also contribute to sustainable agricultural practices by reducing the dependency on chemical pesticides and improving crop yield and quality under diverse environmental conditions. Moving forward, the integration of these technologies promises to address the challenges of food security and environmental sustainability more effectively. However, it also necessitates careful consideration of regulatory, ethical, and ecological impacts to ensure that the benefits of genetically improved crops are realized without unintended consequences. The future of mustard breeding, therefore, lies in a balanced approach that leverages both traditional knowledge and innovative technologies to create resilient agricultural systems.

References

1. Agnihotri A, Gupta K, Prem D, Sarkar G, Mehra VS, Zargar SM. Genetic enhancement in rapeseed-mustard for quality and disease resistance through in vitro techniques. Proceedings of the 16th Australian Research Assembly on Brassicas, Ballarat, Australia. 2009 Sep;28:119.
2. Pandey H, Shukla RK, Pandey TD, Raj S. Effect of different rates of nitrogen and sulphur on growth attributes in Indian mustard (*Brassica juncea* L.). International Journal of Agricultural Nutrition. 2020;2(2):32-34. DOI: 10.33545/26646064.2020.v2.i2a.36
3. Chauhan JS, Singh KH, Singh VV, Kumar S. Hundred years of rapeseed-mustard breeding in India: accomplishments and future strategies. Indian Journal of Agricultural Sciences. 2011 Dec 1;81(12):1093-109.
4. Yadav R, Singh P, Sandhu PS, Pant U, Avtar R, Radhamani J, Rao SK, Rana JC. Identification and evaluation of Indian mustard genotypes for white rust resistance and agronomic performance. Indian Journal of Genetics and Plant Breeding. 2018 Feb 25;78(01):81-9.
5. Choudhary V, Jambhulkar SJ. Genetic improvement of rapeseed mustard through induced mutations. In: Breeding Oilseed Crops for Sustainable Production. 2016 Jan 1. Academic Press. pp. 377-390.
6. Thakur AK, Singh KH, Sharma D, Parmar N, Nanjundan J. Breeding and genomics interventions in Ethiopian mustard (*Brassica carinata* A. Braun) improvement–A mini review. South African Journal of Botany. 2019 Sep 1;125:457-65.
7. Rose CW, Millwood RJ, Moon HS, Rao MR, Halfhill MD, Raymer PL, Warwick SI, Al-Ahmad H, Gressel J, Stewart CN. Genetic load and transgenic mitigating genes in transgenic *Brassica rapa* (field mustard)× *Brassica napus* (oilseed rape) hybrid populations. BMC Biotechnology. 2009 Dec;9:1-4.
8. Hervé MR. Breeding for insect resistance in oilseed rape: Challenges, current knowledge and perspectives. Plant Breeding. 2018 Feb;137(1):27-34.
9. Panjabi P, Yadava SK, Kumar N, Bangkim R, Ramchiary N. Breeding *Brassica juncea* and *B. rapa* for sustainable oilseed production in the changing climate: progress and prospects. Genomic Designing of Climate-Smart Oilseed Crops. 2019:275-369.
10. Gangapur DR, Prakash BG, Hiremath CP. Genetic diversity analysis of Indian mustard (*Brassica juncea* L.). Electronic Journal of Plant Breeding. 2010;1(4):407-13.