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Review

Sustainable Practices in Mustard (*Brassica juncea* (L.) Czem) Farming: A Comprehensive Review

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ABSTRACT

Purpose: *The detailed analysis explains how new strategies and technology can change Brassica juncea farming, creating a future where making money goes hand in hand with sustainable practices, ensuring food security and protecting the environment.*

Research Method: *Several renowned papers were reviewed to explain a series of recommendations that not only include the adoption of biofertilizers, integrated pest management, crop rotation but also various value-added processing to elevate the economic viability of the mustard crop.*

Findings and Values: *Mustard is an important oilseed crop that has global economic significance, whose transformative changes meet with the contemporary challenges of sustainability and resource efficiency. This review paper explains various sustainable practices that are essential in enhancing the agroeconomy of mustard farming. We study the integration of precision agriculture, nutrient management, and innovative planting techniques that would collectively aim not only to intensify crop yield and quality but also ensure long-term environmental stewardship. The different precision agriculture technologies, like remote sensing and data analytics, offer a real-time insight into crop health, which aids thorough application of irrigation and fertilizers. Different drought-tolerant varieties and genetic improvements in mustard plants provide opportunities to combat water scarcity and boost crop resilience. The study also clearly states that various climate-smart agricultural techniques, including agroforestry and agroecological practices, enhance biodiversity and help mitigate the effects of climate change.*

Keywords: *Climate resilience, Nutrient management, Organic and bio-fertilizers, Sustainable agriculture.*

INTRODUCTION

Brassica juncea belongs to the family *Brassicaceae*. The mustard crop is significant with various usages, as it is a valuable source of cooking oil. The different types of mustard varieties grown in diverse climatic conditions and soil types make it a versatile and hardy crop. The current review paper explains various aspects of mustard farming, including its history, cultivation practices, and the uses of mustard crops (Winkowska *et al.* 2019). Since mustard farming is complicated, this article covers important farming tasks that both farmers and consumers should know.

As agricultural knowledge expands and new technologies emerge, mustard farming continues to evolve. During the past few years, people have been more interested in growing mustard using

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sustainable and organic methods (Dwivedi & Mishra 2020). Experts and farmers are working hard to create methods that protect the environment and raise the efficiency of growing mustard (Jat *et al.* 2021). Researchers are especially interested in using cover crops in mustard farming. Cover crops play a part in limiting weeds, improving soil health and encouraging biodiversity and the health of the environment. Mustard farming can be greatly improved by planting cover crops, which lead to better soil structure and lower chemical use.

Mustard plants seem promising in biofumigation, an approach where chemicals from the plants help to reduce both pests and pathogens in the soil (Abdallah *et al.* 2020). This approach fits with the goals of sustainable agriculture and has started to interest many farmers. Mustard farming is a field that offers much potential for creating new, sustainable ideas. The review describes how the growing use of technology affects the future of mustard farming.

Mustard (Brassica juncea) varieties and cultivation practices

There are three types of mustard: a bright yellow version for condiments and dark brown or black mustard, which frequently appears in Asian meals. There are specific traits to look for and requirements for every type of plant. Different types of mustard can grow best in particular climates and soil types; certain varieties cope well with drought, whereas others do better with frost (Wysocki *et al.* 2002).

To get the best yields, attention should be given to planting depth, how plants are spaced, and proper nutrient use. It is necessary to understand and change these practices depending on the type of mustard being grown (Kumar *et al.* 2020). Creating hybrid and genetically modified types of mustard that resist diseases and have more oil results in greater production and reduces the chances of pests and diseases. Recent differences in mustard are making a big impact on how mustard farming progresses.

They increase farmers' ability to work productively and toughly, helping them cope with new farming situations. Studying the many types of mustard and the methods used to grow them supports farmers in decision-making. It is shown that proper ways of feeding and planting are essential to boost growth, harvest, and profits (Shekhawat *et al.* 2012).

Meena and Sharma (2019) provided useful information about improving mustard farming in India by assessing the extent of adoption and identifying adoption gaps in recommended mustard production technologies among farmers in Bharatpur, Rajasthan. Their study highlighted the levels at which farmers implemented modern practices and revealed where significant lapses occurred, thereby pointing to areas requiring targeted intervention.

These insights are particularly important for policymakers, as they provide a foundation for designing support mechanisms and policies aimed at promoting the adoption of effective agricultural technologies. Furthermore, the findings are instrumental for extension workers, enabling them to tailor training and awareness programs that address specific knowledge and implementation gaps among farmers. For researchers, the study offers a practical framework to explore barriers to technology adoption and to develop strategies that enhance mustard productivity and sustainability in similar agro-climatic regions.

Nutrient management in mustard farming

To enhance mustard crop cultivation, there is a great need for proper nutrients for the mustard crop. Nutrient deficiency in mustard can lead to yield loss (Singh *et al.* 2021). Experts have been collaborating to determine the most effective methods of combining organic materials such as farmyard manure, worm compost, and plant-based compost with conventional chemical fertilizers to optimize soil conditions for mustard plants.

This mix helps the plants to grow better and even increases the size and quality of mustard seeds (Bindhani *et al.* 2020). If there is both chemical and organic nutrient application in the crop, then it not only enhances the crop yield

Table 1. Different modern varieties of mustard along with other agronomic characters.

Variety	Duration (days)	Type of Cultivation	Suitable Area	Characters	Yield (qt/ha)
Vinay (B-9)	90–95	Rainfed	West Bengal & Eastern states	Oil 46%	12–14
P.S-66	110	Irrigated	Northern Gujarat	Oil 46%	12–14
K-88	130–132	Irrigated	Central & Western U.P	Oil 43%	14–18
T-151	120–125	Irrigated	Eastern U.P	Oil 46%	14–15

Source: https://www.ikisan.com/up-mustard-varieties.html

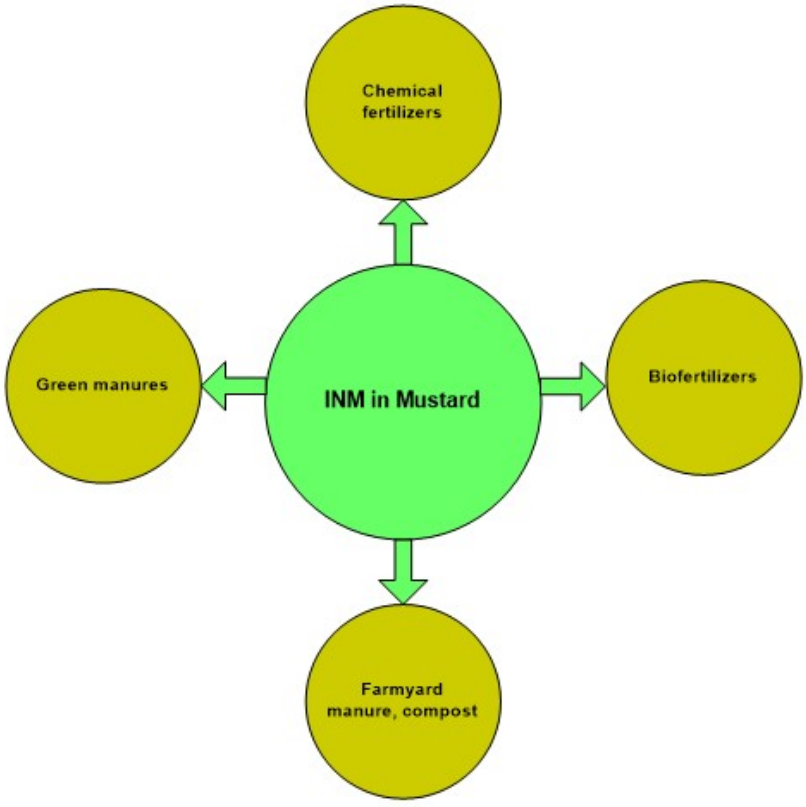

Figure 1. Integrated nutrient management in mustard farming (Bora *et al. 2020*).

Table 2. Mustard varieties along with fertilizer doses.

Variety	N (kg/ha)	P (kg/ha)	K (kg/ha)	Method
Mustard / sarson (irrigated)	80–150	60	20	Half basal + half top dressing, 30–35 days after sowing (Srity *et al.* 2024)
Mustard / sarson (Rainfed)	40–60	25	–	All basal placed (Srity *et al.* 2024)

Source: https://www.ikisan.com/up-mustard-nutrient-management.html

to a significant extent but also reduces the cost of cultivation. Also, different biofertilizers such as *Azotobacter chroococcum* and *Azospirillum brasilense* will grab nitrogen from the air, which turns out to be a beneficial move for healthier mustard plants without affecting the environment (Ren *et al.* 2021). With the need for more oilseeds in India and trying to cut down on costly chemical fertilizers, blending them with farmyard compost and these wonderful bacteria appears a solid plan for greener farming (Patel *et al.* 2020).

Planting methods in mustard cultivation

Effective mustard cultivation greatly depends on selecting the most appropriate planting method, as it directly influences seed placement, weed management, crop establishment, and overall yield. Common planting techniques include drill seeding, broadcasting, and transplanting. Drill seeding, which uses tools like air seeders or double disk-opener press drills, places seeds accurately at shallow depths (usually between ½ and 1½ inches), helping them grow evenly and establish better. Broadcasting, where seeds are scattered over the soil and lightly incorporated, is less precise but can still yield satisfactory results with adequate seed-to-soil contact (Mustard 21 Canada 2025).

Although less common, transplanting mustard seedlings has shown potential to enhance early maturity and yield in conditions where moisture is limited (Ali *et al.* 2012). Beyond planting methods, sustainable mustard production increasingly emphasizes soil conservation. Reduced tillage and no-till planting are important types of conservation agriculture, as they help to preserve the soil, increase organic matter, and let more water easily flow into the soil, improving it able to endure a variety of weather (Mondal *et al.* 2021). Seed drills that place seeds accurately, along with conservation methods, guarantee appropriate seed placement, proper growth rate, and higher yields. As a consequence, using the latest technologies and soil approaches has made farming mustard more successful and environmentally friendly.

- Broadcast Seeding: Mustard seeds are distributed evenly throughout the field in this method. Although it's inexpensive and simple, this method can make planting uneven and allow weeds to compete if the field is large.
- Drilling: Drilling means placing mustard seeds in rows that are far apart from each other using seeding equipment. Planting seeds closely following this method reduces the threat of weeds, helps manage resources well and allows better seed placement, so it is preferred by farmers.
- Transplanting: Nurseries grow the seedlings, and they are moved to the field at a different stage. Plants spaced with this method are easier to arrange and weeds are easier to manage, though it takes more effort and resources to manage the nursery (Ali *et al.* 2012).

The selection of an effective planting system for mustard should consider the size of the farm, the resources available, and the primary objectives. Depending on the crop and growing conditions, one can employ various planting techniques, each offering advantages. According to (Mondal

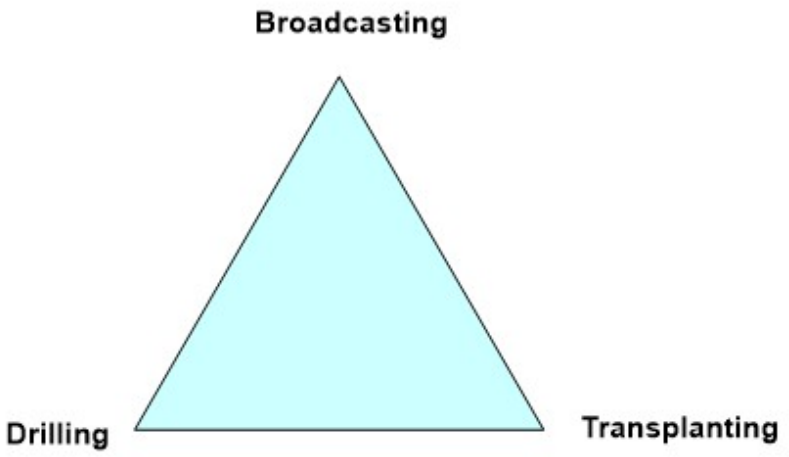

Figure 2. Different planting methods of the mustard crop.

et al. (2021), no-till and reduced tillage methods protect soil structure, reduce topsoil loss, and promote crop recovery from stress over time. Modern farming equipment, including seed drills and mechanical planters, enables precision and promotes more uniform crops, which can lead to higher yields. Implementing the right planting techniques alongside new technologies can significantly enhance mustard production and support sustainable agriculture (Ali *et al.* 2012).

Comparative analysis of mustard planting methods

Conservation tillage using planters and seed drills helps cultivators manage resources, establish crops, and place seeds properly. It improves the condition of soil, extends its work life, allows for higher yields, and saves money through its protective effect on soil (Mondal *et al.* 2021). Applying *Azotobacter chroococcum* and *Azospirillum brasilense* along with organic and inorganic fertilizers handles the problem of not enough nutrients (Singh *et al.* 2023). It improves the size, quality, and productivity of both bulb and mustard crops and provides nitrogen that non-legume crops can use without chemicals (Singh *et al.* 2021). Due to being sensitive to drought and water stress, irrigation is very important for growing mustard crops (Rathore *et al.* 2020a). For situations where rainfall is scarce, the correct irrigation water/crop potential evapotranspiration (IW/CPE) ratio to use is 1.2. Hydrogel usage helps to increase production efficiency, net returns, and profitability under rainfed conditions. It guarantees that plants receive water directly at their roots, minimizing waste. Mulching keeps the ground wetter for a longer time without much water being evaporated. Using organic mulches helps reduce weeds and control the heat of the soil. Better irrigation, right fertilization, and proper seed sowing support the rise in mustard growth and harvest.

Economic impacts of efficient mustard farming

Optimizing agronomic practices in mustard cultivation has been shown to significantly enhance crop yield and profitability. Modern approaches, including precise irrigation scheduling, balanced nutrient management, and timely sowing, contribute to improved productivity and resource use efficiency. According to Akanksha *et al.* (2021), effective irrigation practices increase mustard yield and quality and improve nutrient uptake efficiency, thereby maximizing the return on fertilizer investment. Similarly, Rathore *et al.* (2020b) emphasized that the integrated use of water and nutrient management practices results in higher economic returns by enhancing input use efficiency. Additionally, using hydrogels and superabsorbent polymers that hold onto soil moisture helps to water crops less often

while still keeping them healthy, especially in areas with little water. These interventions collectively contribute to sustainable mustard production through improved water use efficiency, optimized nutrient application, and reduced input costs.

Additionally, using farming methods that focus on keeping the soil healthy and preventing land damage has been shown to help keep farming productive over the long term and lower the need for expensive soil repairs (Kumar *et al.* 2023, Singh & Verma, 2024). Keeping the soil healthy and full of organic matter by using less tillage, rotating crops, and adding organic materials helps nutrients move through the soil and keeps water in it, which leads to better crop yields.

Integrating efficient irrigation, balanced fertilization, and precision planting methods not only minimizes input costs but also enhances resource-use efficiency (Sharma *et al.* 2024). Collectively, these sustainable management strategies increase profitability for mustard growers and promote environmental stewardship by ensuring soil longevity and ecological balance in agroecosystems (Joshi *et al.* 2024).

RECOMMENDATIONS FOR SUSTAINABLE AND PROFITABLE MUSTARD CULTIVATION

Based on the study of different researchers' planting methods and nutrient management in mustard farming, several recommendations can be made for sustainable and profitable mustard cultivation (Gupta *et al.* 2020, Hajimirzajan *et al.* 2021). These include:

- If a farmer uses precision agriculture, distant detection and data collection allow for better irrigation and fertilizer usage. These technologies provide real-time data on crops, water, and nutrients so that farming resources can be applied with higher accuracy.
- Farmers ought to use varieties of mustard that can withstand both a lack of water and stresses from the environment.
- Adopting climate-smart agriculture practices enhances resilience to climate change and promotes biodiversity (Hajimirzajan *et al.* 2021).
- Increased use of organic biofertilizers should reduce the reliance on chemical fertilizers to promote soil health and reduce environmental effects due to intensive chemical use (Choden & Ghaley 2021).
- Better results can be achieved by using cultural, biological, and mechanical techniques that address the problem without causing more environmental damage or affecting biodiversity.
- Crop rotation and diversification—including cover crops and legumes—should be practiced to improve soil health, break pest and disease cycles, and enhance overall productivity.
- Post-harvest and value-added processing should be implemented to maximize profits and minimize losses. This involves proper storage, packaging, and processing techniques to maintain mustard quality and explore value addition opportunities (Gupta *et al.* 2020).
- Integrated weed management should be practiced to avoid dependency on chemicals. This includes manual weeding, biocontrol agents, and the use of bioherbicides.
- Extension agencies should provide adequate technical guidance and support through training and education. Farmers can enhance their knowledge and skills in mustard farming systems through exposure to best practices (Singh *et al.* 2021).

CONCLUSION

In the future, mustard farming has the potential to achieve advancements in sustainable practices of crop growing and technology. The agricultural industry continues to face several difficulties, such as water deficit and environmental degradation. The adoption of innovative techniques will have a crucial impact

on shaping the future of mustard cultivation. Among various factors, the important one is the integration of precision agriculture technologies such as remote sensing and data analytics to optimize irrigation and nutrient management. These innovative technologies can provide farmers with real-time information on crop health, moisture levels, and nutrient requirements, which will allow a more precise and targeted application of resources. Research and development in drought-tolerant mustard varieties and genetic improvement can lead to the cultivation of resilient crops that require less water and exhibit greater tolerance to environmental stresses. These will significantly contribute to mitigating the impact of water scarcity on mustard farming while ensuring consistent yields and economic stability for farmers. The adoption of climate-smart agricultural practices, which will include agroforestry and agroecological approaches, can also play a significant role in enhancing the resilience of mustard farming systems to climate change while promoting biodiversity and ecosystem services. Hence, the future of mustard farming lies in the integration of innovative technologies, sustainable practices, and genetic advancements, which will address the challenges of water deficit, environmental sustainability, and economic viability. By embracing this development, farmers can secure the long-term productivity and profitability of mustard cultivation while contributing to the broader goals of sustainable agriculture and food security.

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