Synergistic Effects of Organic Preparations and Integrated Nutrient Management on the Growth, Yield, and Quality of Indian Mustard (Brassica juncea L.)

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ABSTRACT

Indian mustard (*Brassica juncea* L.) is a preeminent winter oilseed crop crucial to the global edible oil economy, historically reliant on intensive chemical fertilization to maximize seed and oil yields. However, prolonged dependency on synthetic NPK (Nitrogen, Phosphorus, and Potassium) fertilizers has precipitated severe secondary consequences, including the depletion of soil organic carbon (SOC), microflora collapse, and subsequent yield stagnation. This paper evaluates the agronomic, physiological, and economic impacts of integrating diverse organic preparations-ranging from bulky organic manures (Farm Yard Manure, Vermicompost) to microbial biofertilizers (*Azotobacter*, Phosphate Solubilizing Bacteria) and liquid bio-stimulants (Jeevamrit, Vermiwash, Panchagavya)-into mustard cultivation. A review of randomized block design field experiments demonstrates that an exclusively chemical approach degrades long-term soil health, while a purely organic approach often sustains a short-term yield penalty due to the slow mineralization of essential nutrients. Consequently, the Integrated Nutrient Management (INM) framework emerges as the most viable agronomic strategy. Substituting 25% to 50% of the Recommended Dose of Fertilizers (RDF) with high-quality organic sources, augmented with biofertilizer seed priming or soil

inoculation, significantly optimizes vegetative growth parameters such as plant height and primary/secondary branching. Furthermore, liquid organic foliar applications during critical phenological stages (branching and flowering) delay leaf senescence and enhance the grain-filling period. This synergistic approach not only maximizes final seed yield and oil content largely by replenishing vital secondary nutrients like Sulphur but also yields the highest Benefit: Cost (B:C) ratio. Ultimately, the strategic application of organic preparations is not merely an alternative farming method, but a scientifically imperative intervention to restore rhizosphere health, ensure climate resilience, and sustain the long-term productivity of mustard cultivation.

INTRODUCTION

Indian mustard (*Brassica juncea* L.) occupies a strategic position in the global agricultural landscape, serving as a primary source of edible oil, particularly across the Indian subcontinent and parts of Asia. Valued for its robust adaptability to sub-tropical winter (*Rabi*) climates and limited moisture conditions, the crop is indispensable to the agricultural economy. The seeds yield a high oil content, typically ranging between 38% and 42%, which is rich in essential polyunsaturated fatty acids. Beyond its nutritional profile, mustard holds significant commercial value as a rotational crop, providing residual biomass and contributing to the economic stability of millions of smallholder farmers. However, as global populations expand, the pressure to intensify mustard production has exposed the critical vulnerabilities of modern, conventionally managed agricultural systems.

For the past several decades, the overarching strategy to achieve high crop yields has been anchored in the heavy application of synthetic inorganic fertilizers, specifically Urea, Diammonium Phosphate (DAP), and Muriate of Potash (MOP). While this chemical-intensive paradigm successfully addressed immediate food and oil security deficits, it has exacted a severe toll on soil health and ecological sustainability (Singh & Pal, 2018). The continuous, unbalanced application of chemical fertilizers without the parallel incorporation of organic matter has led to widespread soil fatigue. Agronomic surveys indicate a precipitous decline in Soil Organic Carbon (SOC), widespread disruption of the natural soil physical structure resulting in

increased bulk density, and a near-total collapse of beneficial soil microflora (Kumar *et al*., 2020). Consequently, mustard farmers are currently facing a phenomenon of yield stagnation; they are compelled to apply increasingly higher volumes of chemical inputs merely to maintain historical yield baselines, severely reducing their profit margins and exacerbating environmental hazards such as nitrate leaching.

Furthermore, the exclusive reliance on synthetic NPK fertilizers fundamentally neglects the secondary and micronutrient requirements of the crop. Mustard is a heavy feeder of Sulphur, a critical macronutrient directly responsible for the biosynthesis of

amino acids (cysteine and methionine) and glucosinolates, which impart the characteristic pungency and drive overall oil synthesis. Traditional chemical fertilizers do not supply Sulphur, leading to widespread deficiencies in intensively cropped soils (Sushanth *et al*., 2025). This specific nutritional gap underscores the urgent necessity of pivoting toward organic preparations, which inherently possess a broader, more balanced spectrum of trace minerals.

Organic preparations encompass a diverse array of inputs designed to holistically nourish both the plant and the soil matrix. These include bulky organic manures like Farm Yard Manure (FYM) and Vermicompost, which act as primary soil conditioners. By increasing the soil's porosity and water-holding capacity, these bulky organics create an optimal physical environment for root proliferation. Concurrently, microbial biofertilizers such as *Azotobacter* and Phosphate Solubilizing Bacteria (PSB) serve as living nutrient mobilizers. *Azotobacter* fixes atmospheric nitrogen directly in the rhizosphere, while PSB

secretes organic acids to dissolve locked soil phosphates, transforming them into plant-available forms (Kumar *et al*., 2021). More recently, the introduction of fermented liquid organics such as Jeevamrit, Vermiwash, and Panchagavya has revolutionized organic applications. These liquid bio-stimulants are rich in naturally occurring plant growth regulators (auxins, cytokinin's) and immediately available soluble nutrients, allowing for rapid physiological responses when applied as seed primers or foliar sprays (Das *et al*., 2023).

Despite their ecological benefits, a sudden, complete transition to purely organic farming presents significant challenges, primarily a temporary "yield penalty" caused by the slow microbial decomposition required to release nitrogen from solid organic matter (Kumar *et al*., 2020). Because mustard has a rapid vegetative growth phase, it requires immediate nutrient availability that strictly organic

systems often struggle to provide in depleted soils. To bridge this divide, modern agronomy advocates for Integrated Nutrient Management (INM). INM is a synergistic approach that combines a reduced, targeted basal dose of chemical fertilizers to meet the crop's immediate peak demands, alongside organic preparations to sustain long-term nutrient release and rebuild soil health (Singh & Pal, 2018; Tal *et al*., 2024). Therefore, the core objective of this paper is to critically analyze recent field data and evaluate how the strategic integration of solid and liquid organic preparations affects the growth attributes, yield components, oil quality, and overall economic viability of Indian mustard.

CONCLUSION

The transition from purely chemical farming to Integrated Nutrient Management (INM) is no longer an optional ecological initiative; it is an agronomic necessity for the sustained cultivation of Indian mustard (*Brassica juncea*). Extensive field research conclusively

demonstrates that relying solely on synthetic NPK fertilizers degrades soil organic carbon, suppresses microbial activity, and fails to provide the Sulphur crucial for optimal oil synthesis. Conversely, while purely organic treatments restore soil health, their slow nutrient mineralization often results in short-term yield penalties (Kumar *et al*., 2020).

The integration of 25% to 50% organic nutrient sources particularly through high-efficiency inputs like Vermicompost combined with microbial biofertilizers (*Azotobacter* and PSB) and a reduced chemical dose, establishes a perfect agronomic synergy (Kumar *et al*., 2021). This integrated approach consistently maximizes plant height, branching, and total siliquae per plant. Furthermore, the strategic application of liquid organic bio-stimulants, such as Panchagavya and Vermiwash, actively delays leaf senescence and dramatically enhances the seed grain-filling process (Das *et al*., 2023). Ultimately, the incorporation of organic preparations not only achieves the highest seed yield, premium oil content, and maximum economic return (Benefit: Cost ratio) for the farmer, but it also actively rehabilitates the rhizosphere. By adopting these organic integrations, modern agriculture can ensure high crop productivity while preserving vital soil fertility for future generations. (Tal *et al*., 2024; Sushanth *et al*., 2025).

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