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Organo-Mineral Fertilizers (OMFs) for Sustainable Agriculture

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Abstract

Finding an appropriate equilibrium between intensification and sustainability is one of agriculture's main objectives. Three key factors i.e., the exponential growth in global population, climatic unpredictability, and soil degradation, are essential factors that require the development of novel agricultural practices in order to ensure food security. Organo-mineral fertilizers (OMFs) have been suggested as a viable strategy in this regard. OMFs are novel fertilizer compounds that combines the advantages of synthetic and organic fertilizers as they enhance the physical properties of soil, boost agronomic efficiency, and have an impact on nutrient release coinciding with the crop's growth phases. The coprocessing of organic and mineral materials is the foundation of the highly versatile OMF production processes. It is unique in in using systemic methodologies for waste valorisation in order to produce economically viable, environmentally sustainable goods that are in line with the principles of the bio circular economy.

Keywords: Organo-mineral fertilizers, chemical fertilizers, sustainable agriculture, soil fertility

Introduction

Agriculture has been transformed by the application of fertilisers to increase crop yields. High yields necessitate substantial agronomic inputs, with mineral fertilizers being one of the most expensive. When chemical fertilizers (CFs) are used indiscriminately to increase the production, it severly jeopardizes the soil fertility, the soil environment. However, the soil microbial community plays significant role in promoting soil health and plant growth (Martins *et al*., 2017), especially CFs like N and P fertilizers, have a significant negative effect on soil microbial community. In agricultural production systems, organic compounds (organic

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fertilizers OFs) are an alternative to using mineral fertilisers or chemical fertilizers (CFs). Any product derived from plants, animals, urban or industrial residues, which is composed of degradable carbon, and may also be any substance that is present in the as soil known organic fertilizers (OFs) microorganisms, excretions of fauna and everything that turns into humus after the decomposition (Chem, 2015). Though, the exclusive use OFs is practicable only for some crops or in small areas; typically, the large amounts of OFs required to meet the nutritional needs to accomplish the nutritional requirement, which would increase the cost of freight and turn organic fertilization impracticable.

Sustainable farming practices can maintain soil fertility and productivity while reducing the depletion of natural resources. Furthermore, they safeguard against soil degradation, facilitate the development of soil health (Su R *et al*, 2022; Himics *et al.*, 2018). Recently, integrated plant nutrition (IPN), often referred to as integrated nutrient delivery or integrated nutrient management system, has been recommended by FAO. Both organic and inorganic fertilisers in addition to a soil conservation farming method, are utilised to supply nutrients to crops.

What are OMFs

Anon (2013) defines an organo-mineral fertiliser (OMF) as a fertiliser that is obtained by mixing or blending of organic fertilisers or soil improver with inorganic fertilisers that have a declarable amount of one or more main nutrients. These OMFs should include at least 10% of the major macronutrients (N, P, and K) or these nutrients in conjunction with additional nutrients (NP, NK, PK, or NPK). OMFs are abundant in the minerals needed for agricultural growth (Aguilar *et al.*, 2019).

Researchers and practitioners in modern agriculture are actively seeking sustainable and efficient nutrient management practices that go beyond conventional fertilizers. Organo-mineral fertilizers are a promising alternative, providing a combination of organic and mineral components to enhance the supply of nutrients and soil health. Organo-mineral fertilizer formulation is variable as it is influenced by the amount of organic and mineral source used for its composition. For several decades, traditional synthetic fertilizers have played a crucial role in improving soil fertility and increasing crop productivity. Nevertheless, the widespread utilization of these chemicals has sparked apprehension regarding the negative impact on the environment, the potential for nutrient runoff, and the depletion of soil. To address these

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challenges, the idea of organo-mineral fertilizers has gained momentum, harnessing the advantages of organic matter and mineral nutrients to enhance nutrient absorption, soil structure, and plant health (Crusciol *et al*., 2020).

OMFs, as compared to CFs, can decrease the loss of some nutrients, such as potassium leaching and nitrogen volatilization. They can also minimise the fixation of phosphorus by oxides of iron and aluminium that are abundant in weathered soils (Rheinheimer *et al*., 2008). OMFs releases nutrients into the soil in a manner that facilitates plant uptake and affects nutrient release during a time that corresponds with the crop's growth stage (De Souza *et al.*, 2017). In addition, the benefits of organo-mineral fertilisation extend beyond the crop season in which it is applied; they also have a cumulative residual impact in succeeding years that improves the soil's chemical, physical, and biological properties (Ghosh *et al*., 2009).

Nutrient Availability and Plant Uptake by OMFs

Organo-mineral fertilizers offer a compelling solution for plant nutrition by simultaneously enhancing nutrient availability and uptake. The organic fraction improves soil structure and nutrient-holding capacity, making nutrients more accessible to plants (DeLuca et al., 2000). Meanwhile, the mineral component provides readily available nutrients for immediate plant response (Havlin *et al*., 2013). Furthermore, combining organic and mineral components promotes efficient nutrient cycling within the soil, reducing losses through leaching or volatilization (Bardgett *et al*., 2010). These combined benefits translate to increased plant growth and productivity, surpassing results achieved with solely inorganic fertilizers (Khan *et al.*, 2021). The integrated approach fosters sustainable agricultural practices, particularly in regions facing resource limitations, by reducing dependence on expensive and potentially harmful inorganic fertilizers (Yadav *et al.,* 2017). However, optimizing organo-mineral fertilizers' effectiveness necessitates carefully considering factors like fertilizer composition, application techniques, environmental conditions, nutrient interactions, and variations in plant nutrient requirements (Havlin *et al*., 2013). Farmers can leverage organo-mineral fertilizers to achieve optimal crop production while promoting long-term soil health by understanding these nuances.

Impact of Soil Health and Fertility by OMFs

Organo-mineral fertilizers provide a comprehensive solution for plant nutrition by focusing on soil health and nutrient availability. The organic matter acts like a sponge, absorbing and holding essential nutrients, making them readily available for plants over a sustained period (Khan *et al.*, 2021). The organic matter stimulates microbial activity in the soil, breaking complex compounds into simpler forms that plants can efficiently utilize (Tian *et al.*, 2014). This fosters efficient nutrient cycling, ensuring a continuous supply of nutrients for plant growth. Organic matter improves soil aggregation, creating pore spaces that enhance aeration, water infiltration, and drainage. This "sponge" effect also improves water availability for plants during dry periods. It helps prevent soil erosion by promoting soil stability (Havlin et al., 2013). It is essential to consider how the organic component can influence soil pH, directly affecting nutrient availability (Singh *et al.*, 2011). Some organo-mineral fertilizers exhibit a buffering effect, helping to stabilize pH levels and prevent fluctuations that could disrupt plant nutrient uptake. Additionally, organic matter can help reduce soil alkalinity, particularly in high-pH soils (Havlin *et al.*, 2013). Combining these benefits, organo-mineral fertilizers create a synergy that fosters thriving plants and sustainable soil health.

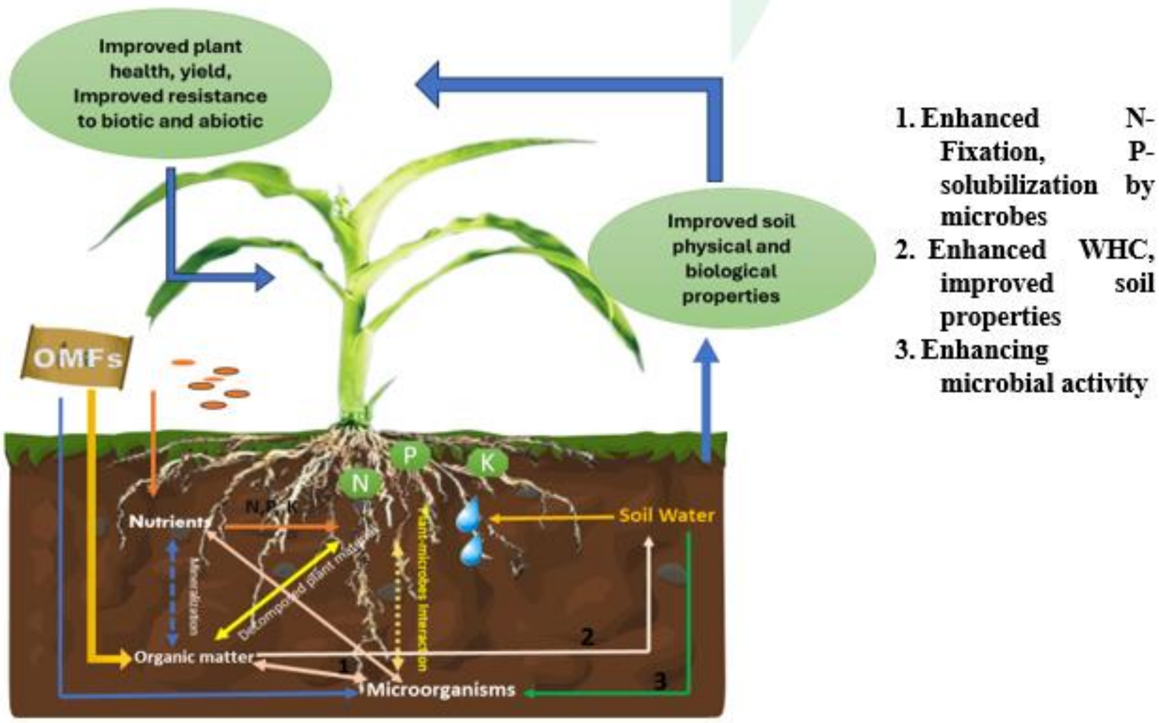

Figure 1: The effect of organo-mineral fertilizers (OMF) on soil and plant

Compatibility with Other Inputs

The compatibility of organo-mineral fertilizers with other agricultural inputs depends on the input type and the desired effect. Studies have shown combining organic and mineral fertilizers

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can significantly impact productivity and agronomic efficiency. Still, the effects on yield variability and soil organic carbon depend on the quality of the organic resource input (Gram, 2023; Bouhia, 2022). Organo-mineral fertilizers are compatible with biosolids, urea, and biochar fertilizers, and they have been found to produce yields and impacts on soil health comparable to mineral fertilizers (Banye, 2020). Using organo-mineral fertilizers can also reduce the loss of some nutrients, such as nitrogen volatilization, phosphorus fixation, and potassium leaching (Burak, 2023). Ultimately, the compatibility of organo-mineral fertilizers with other agricultural inputs depends on the specific inputs being used and the desired outcome.

Table 1: Compatibility of various inputs of OMFs

Mineral fertilizer/ organic fertilizer source	**Compatibility**	**Refences**
Urea	Urea is a widely used nitrogen source that can enhance the nutritional value of organo-mineral fertilizers	Bouhia, 2022
Superphosphate	Superphosphate is a popular phosphorus source that can be combined with organo-mineral fertilizers to provide balanced nutrition	Burak, 2023
Potassium sources	Potassium chloride, sulfate, or other potassium sources can be combined with organo-mineral fertilizers to supply potassium	Bouhia, 2022
Gypsum	Gypsum can help correct soil structure and balance the nutrient levels in organo-mineral fertilizers	Banye, 2020
Biochar	Biochar can improve soil structure, water retention, and nutrient cycling when combined with organo-mineral fertilizers	Bouhia, 2022
Biosolids	Biosolids derived from wastewater treatment facilities can be used as a source of organic	Banye, 2020

	matter and nutrients when combined with organo-mineral fertilizers	

Conclusion

India urgently needs to optimise nutrient cycles to meet global food demands while minimising negative consequences on health, ecosystems, and climate in order to accomplish the 2030 Sustainable Development Goals (SDGs). Strategies for separate waste recycling and optimisation are also required. This calls for switching to a more balanced and sustainable strategy to nutrient management that prioritises both the environment and the economy. The OMF focuses on recycling and preserving natural cycles with the goal of sealing nutrient loops and reducing leakage. Although the concept of a circular nutrient economy is frequently discussed, there is still little evidence of it being used in practice in India. Measures like waste recycling and tax incentives for converting waste into money might encourage the adoption of the OMF. Although waste-based products may have higher nutrient prices and require post-treatment, their environmental benefits, including waste reduction and greenhouse gas emissions, should be factored into economic feasibility studies. Governments must figure out the advantages of of meeting nutrient targets for ecosystems, climate mitigation, and human health while shifting towards OMF.

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