Short- and long-term impacts of fertilizer types

Hans Langeveld, Manisha Lamichhane, Laura Laroche and Fiona Loomis

Introduction

Fertilizers play a crucial role in enhancing agricultural productivity as they provide essential plant nutrients and improve soil properties. They have both short-term and long-term effects on soil, plant, and ecosystems. Short-term impacts like provision of crop nutrients generate results within one growing period. Long-term impacts, including effects on soil pH, soil structure (soil organic matter, water holding capacity, Cation Exchange Capacity (CEC)) and soil life (bacteria, fungi and other) can be observed only after several years.

This factsheet has been prepared in the Organic Fertiliser Valorisation Implementer (OFVI) project part of the ABC program (https://www.ofvi-abc.nl/) which aims to stimulate the production and use of bioslurry and Bioslurry Enriched Compost (BEC) in Sub-Saharan Africa. The project follows common definitions of bioslurry and compost production; a distinction is made between fresh and dried bioslurry which loses some of its valuable nutrients. Bioslurry and BEC improve business cases for farmers and bio-digester owners. The factsheet evaluates short- and long-term impacts of the following fertilizers:

- ***Chemical fertilizers***
- ***Bioslurry (fresh and dried)***
- ***Farmyard manure (FYM):*** decomposed dung, urine, litter, and organic materials
- ***Compost :*** a mixture of ingredients used as plant fertilizer prepared by decomposing plant and food waste, recycling organic materials, and manure.
- ***Bioslurry Enriched Compost (BEC)***

Impacts

A review of existing literatures on the impact of different fertilizers on soil properties and crop yield is presented in Table 1.

Table 1: Short- and long-term impacts of different types of fertilizers (source: Langeveld et al., 2023)

Effect	Chemical fertilizer	Farmyard manure	Bio-slurry fresh	Bio-slurry dried	Compost	BEC
Immediate – chemical	Highly positive	Slightly positive	Positive	Slightly positive	Slightly positive	Positive
Long term - chemical	Negative	Slightly positive	Slightly positive	Slightly positive	Slightly positive	Slightly positive
Long term - physical	Moderate negative	Positive	Slightly positive	Slightly positive	Highly positive	Highly positive
Long term - biological	Negative	Positive	Positive	Positive	Highly positive	Highly positive

Short-term chemical impacts refer to immediate plant root access to nutrients.

- ***Chemical fertilizers*** show quick nutrient release, whereas release is slower for many organic fertilizers. Decomposition rates are: 100% for chemical fertilizers, 45% for manure, and 10-15% for compost (Van Opheusden et al. 2021).
- Nutrient (especially nitrogen) supply from ***fresh bioslurry*** and ***BEC*** show a quicker release than from ***compost*** and ***FYM*** (Van der Wurff, 2016; Bonten et al., 2014; Guster et al., 2005). However, drying of ***bioslurry*** typically reduces its nitrogen content (Warnars and Oppernoorth, 2014). In conclusion, nutrient release is quickest from ***chemical fertilizers, bioslurry*** and ***BEC***.

Long-term chemical impacts refers to the way fertilizers affect soil chemistry, for example by increasing or reducing soil acidity which significantly influences nutrient availability in the long run.

- Most crops prefer pH values between 5.5 and 7.5 (Oshunsanya, 2018). Most types of ***chemical fertilizer*** lower the pH while, organic fertilizers like ***manure, bioslurry*** and ***compost*** increase soil pH (Li et al., 2023; Elia et al., 2019; Wang et al., 2019) which is explained by release of basic cations and alkaline substances from organic fertilizers (Lolamo et al., 2023).

Long-term physical impacts refer to changes in soil physical properties such as water holding capacity and CEC. Both are associated with soil organic matter which provides organic binding agents, increasing water retention, soil pores, and aeration (Kumar et al., 2022).

- Organic fertilizers like ***manure, bioslurry*** and ***compost*** positively influence soil structure, organic matter, and CEC (Doyeni et al., 2021; and Mengistu et al., 2017) whereas, ***chemical fertilizers*** has comparatively lower increase in organic matter (Wang et al. 2019).
- ***FYM*** enhances water holding capacity and root growth more effectively than ***chemical fertilizers*** (Mahmood et al., 2017). Also, it is more effective than ***bioslurry*** for long term organic matter enhancement, as lower C:N ratio in ***bioslurry*** cause faster breakdown of organic matter (Nyang'au et al., 2016).

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- ***Compost*** retains 50% of organic matter as persistent humus, while ***bioslurry*** holds only 25-30%. Consequently, humus generated from ***bioslurry*** is less stable and provides less support to the soil matrix than ***compost*** based humus (Van der Wurff, 2016).

Long-term biological impacts refers to the influence of fertilizers on the activity and populations of soil microorganisms such as fungi and bacteria.

- ***Compost*** contains more complex humic substances that positively influence soil microbial population and activity (Ampong et al., 2022). Consequently, soil microorganisms take longer to decompose compost (and make nutrients available for the plant), as compared to ***FYM*** and ***bioslurry*** (Mahajan and Gupta, 2009; Fuchs and Cujipers, 2016).
- Microorganisms, particularly Arbuscular Mycorrhizal Fungi (AMF), have a crucial role in boosting soil stability, organic matter, nutrient availability and crop yield (Mason et al. 2023). Long term use of ***chemical fertilizers*** negatively affects AMF activity, diversity, and structure (Lin et al., 2020 and Xu et al., 2013). In contrast, ***organic fertilizers*** (in particular ***compost***) enhance soil microbial biomass activity, diversity and fungal distribution (Li et al. 2012).
- Organic matter with higher C:N ratios (for example wood) is mostly decomposed by fungi, while lower C:N ratio materials are decomposed by bacteria at a higher speed releasing nutrients available on the short term. ***Compost***, (from materials like wood) have the lowest decomposition rate followed by ***FYM, bioslurry*** and ***chemical fertilizers*** which are already in plant available form on application (Nyang'au et al., 2016, Lin et al. 2012).

Conclusion

Organic fertilizers enhance pH, organic matter, and microbial activity, offering long-term benefits. In contrast, chemical fertilizers, provide immediate nutrients access but can cause soil acidification. The following general order of fertilizer impacts is suggested:

- Short term nutrient availability: chemical fertilizers >> fresh bioslurry & BEC >> dried bioslurry>> FYM >> compost
- Long term impact on soil chemistry: FYM, bioslurry (dried and fresh), compost & BEC >> chemical fertilizers
- Long term contribution to soil structure and biology : compost & BEC >> bioslurry (dried and fresh) & FYM >> chemical fertilizers

It is concluded that organic fertilizers, especially bioslurry and BEC, provide the best balance of short-term and long-term benefits.

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