JMALS

Journal of Medical and Life Science

https://jmals.journals.ekb.eg/

SPBH

Vermicompost is an alternative to chemical fertilizer for soil: a review

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DOI:10.21608/jmals.2025.416704

Abstract

Chemical fertilizers are frequently employed to increase agricultural yields and satisfy the nutritional needs of crops. Unfortunately, they are quite expensive, and their overuse in soil raises production costs while harming the ecosystem and the soil. The rate at which the world's population is growing is concerning. Intense farming, utilizing larger agricultural areas and more chemical fertilizer, had been used to fulfill the rising demand for food. Food and agriculture experts claim that chemical fertilizers are the single most significant factor increasing global agricultural productivity. Crop growth and soil health are greatly affected by intensive land use coupled with continuous and inaccurate application of higher doses of inorganic fertilizers. Bioxidation and stabilization of organic material involving the joint action of earthworms and mesophilic micro-organisms" is the definition of vermicomposting. Worms can consume agricultural waste and reduce its volume when the right circumstances are met.

Keywords: Vermicompost, organic waste, soil, Charles Darwin, plants

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Introduction:

Global consumerism has grown rapidly, which has major negative effects on the environment (1). The buildup of heavy metals in the soil and plant systems may be impacted by fertilization. Fertilizers are absorbed by plants through the soil and can then go up the food chain. Thus, contamination of the air, water, and soil results from fertilizing (2). Heavy metals and naturally occurring radionuclides are thought to be possible sources from the fertilizer sector. It is mostly composed of natural radionuclides such as 238U and 232Th, as well as heavy metals such as Hg, Cd, As, Pb, Cu, Ni, and Cu (3,4). However, the usage of fertilizer has grown rapidly worldwide in recent years, leading to significant environmental issues (5). Heavy metal buildup in the soil and plant system may be impacted by fertilization (6,7). To enter the food chain, plants must absorb nutrients through the soil. Consequently, soil, water, and air pollution are caused by fertilizer (8). To satisfy the demands of the expanding population, food production was greatly enhanced by the excessive use of artificial fertilizers (9). Chemical fertilizers are used in crop production to meet the food needs of 50% of the population. However, because of pesticide residues in food products, this has resulted in environmental damage and health problems (10). With the interest in environmental balance and the need to ensure adequate protection of biological resources, ecosystems, and life-support systems (sustainable development) (11), there was an urgent need to recycle organic waste using earthworms, which are considered a decomposer of plant residues (12). The first to mention the importance of earthworms and consider them soil engineers was Charles Darwin (13). Vermicomposting various organic wastes with earthworms to create a nutrient-rich "organic

Received: December 15, 2024. Accepted: February 18, 2025. Published: March 9, 2025

fertilizer" and using the resulting "chemical-free safe food" to produce food that is both safe and abundant without the use of agrochemicals is revolutionizing the field of vermiculture research (14). The study's objective is to demonstrate the effectiveness and advantages of using organic fertilizers over chemical fertilizers.

Benefits and drawbacks of chemical fertilizers:

A natural or synthetic material called fertilizer includes one or more of the chemical elements such as N, P, and K that promote plant growth and productivity (15). Chemical fertilizers are easier to apply and less expensive than organic fertilizers, but they also influence the soil's naturally occurring microbes, which increase soil fertility (16). Chemical fertilizers come in many forms and are designed to be applied to various soil types for a range of plants and crops (17). Chemical fertilizers are inorganic substances that are partially or completely produced. Enhancing macronutrients like nitrogen (N), phosphorus (P), and potassium (K) will increase plant growth and development and, ultimately, plant production. This is the goal of adding chemical fertilizers to the soil (18). The harms of chemical fertilizers include their ability to produce various greenhouse gases (15). Urea was the chemical fertilizer that produced the most greenhouse gas emissions (almost 60% of all greenhouse gas emissions). This was because it was applied to crops at a reasonably high rate and had relatively high GHG emission intensities during both application and manufacture (19). However, even though chemical fertilizers are primarily responsible for the world's crop production being sufficient, their excessive use is posing serious risks to both current and future generations, including contaminated air, water, and soil, degraded lands, depleted soils, and increased greenhouse gas emissions (20). Because agrochemicals include nitrogen, phosphate, and persistent insecticides, their overuse degrades the quality of soil and groundwater (21). By adding nutrients and enhancing soil quality, organic fertilizers help the soil's chemistry, structure, and biological activity (22).

Vermicomposting and sustainable development:

Vermicompost is an organic fertilizer that is created when organic debris is broken down by red worms, which are often used in this process (23). Vermicomposting, another name for the worm-composting process, is a sustainable and environmentally friendly method of turning organic waste into high-quality, nutrient-rich plant fertilizer (24). You can turn your garbage into a fantastic plant fertilizer. Earthworms and bacteria work together to create vermicompost (VC), an organic fertilizer that resembles peat and has excellent nutritional value, aeration, porosity, and water-holding capacity (25).VC is acknowledged as an efficient plant growth stimulator in addition to managing organic waste (26). Microbial activity in VC increases the availability of micronutrients such as potassium (K), phosphorus (P), and nitrogen (N) (27).

These procedures include the use of native microorganisms to break down larger, more complicated compounds in the raw substrate into smaller, more straightforward ones. Through the process of vermicomposting, organic waste is converted by earthworms and microorganisms into substances that are safe to use as bio fertilizers and soil conditioners. The variables of temperature, moisture, aeration, and pH affect the rate and extent of composting (28). Earthworms are an important component in the development and maintenance of the physical and chemical properties of soil by converting biodegradable materials and organic waste into nutrient-rich vermicompost. Modern agricultural practices alter the physical and chemical composition of the soil environment and thus modify changes in the abundance and composition of earthworm communities (29,30).

Mechanism of manufacturing and working of vermicompost:

Earthworms feed on organic matter on the surface of the soil (leaves) or inside the soil (roots), i.e., the remains of plant parts. After these parts are digested by earthworms (31), they produce decomposed materials called compost, which contain higher levels of nitrogen, phosphorus, and carbon compared to soils that do not contain worms. Earthworms dig and mix the soil with plant remains or organic matter to redistribute nutrients vertically and horizontally in the area in which they are located. This affects the biotic and abiotic properties of soil systems and food webs, which affects communities (32).

The decomposed food materials with the soil enter the mouth of the worm with the help of Rostellum, which leads to an increase in calcium in its blood. Calcium is secreted in the intestine of the worm in the presence of calcific glands along the pharynx, which work to regulate the ion of calcium, which leads to a moderation in the concentration of calcium in the blood, in addition to its role in regulating the acidity of body fluids (33). The vesicle is followed by a thin-walled gizzard, after which the food is ground and absorbed by the intestinal wall. The intestine is surrounded by chloagogen tissue, which manufactures sugar and fats. With the help of the oil glands, the food is released into the general cavity of the animal and then into the body tissues, and the rest is expelled from the body and is known as compost (34).

Vermicomposting requirements and soil standards:

It is necessary to monitor characteristics, including temperature, moisture, pH, airing, particle size, capacity of cationic interchange (CCI), organism matter (OM), nitrogen (N), and C/N ratio to determine if a vermicompost satisfies the requirements for its usage as a soil conditioner (35). The ideal temperature range for *E. fétida* development is between 15°C and 25°C (36). These parameters control every biological activity of the worm. Temperature also affects how the worm lives. The incubation of *L. terrestres* is hindered at low temperatures (3-5°C). Soil moisture is one of the most important factors that help earthworms dig soil tunnels, in addition to the mucus on the surface of their bodies (37). For the worm *E. fetida* to conduct gas exchanges, it needs moisture. The ideal moisture content is between 60% and 80%, which keeps the worm from becoming dehydrated and losing weight (38). Temperature is an important factor in determining and structuring earthworm communities, as the rates of decomposition of organic matter are faster at higher temperatures, which leads to a decrease in organic matter (decomposed leaves, etc.), which leads to the depletion of some earthworms in the region. However, there are types of earthworms that can feed and live in soils that are poor in organic matter and are also able to withstand temperatures of up to 35°C (39). Earthworm casts are a storehouse of nutrients for plants. Increased earthworm activity increases the availability of carbon, which in turn increases the nitrogen and phosphorus available in the casts. This increases earthworm activity and improves the soil aggregates and soil minerals available to plants (40).

Studies:

Vermicomposting is a good method for recycling food and waste, as demonstrated in the study (41). It also has a high organic carbon content (18.83-36.01%) and has the potential to be used as fertilizer (1.16-2.58%) nitrogen, (0.42-1.12%)phosphorus, and 0.61-2.05% potassium. Swiss chard's yield, phytochemical content, and biological activity were assessed in a study that examined the effects of adding chemical fertilizer (ammonium nitrate), compost (vermicompost from cattle manure), and biochar (from wood chips and vineyard pruning residues, respectively) to soil either alone or in combination.

The results of the study showed that vermicompost, either alone or in a mixture with biochar, led to an increase in yield (increased leaf area and plant height) compared to untreated soil or soil treated with chemical fertilizers (ammonium nitrate) (42).

To reduce the use of chemical fertilizers N P K, this study was carried out throughout two consecutive seasons, 2018 and 2019, on the seedless grape variety Superior grown in the experimental farm of the Faculty of Agriculture, South Valley University, Qena Governorate, Egypt, where the soil is sandy clay. Vermicompost and biofertilizers were used to partially replace chemical fertilizers at a rate of 25-75%. According to the findings, providing Superior grapes with vermicompost supplemented with nitrogen, phosphorus, and potassium improved all growth characteristics (shoot length, leaf area, number of leaves/shoots, and leaf mineral content), yielded the highest yield and best-quality fruit for Superior grapes, enhanced the physical and chemical characteristics of the soil, and decreased environmental pollution (43).

Two years of field trials (2003–2005) in a semi-arid tropical setting were used to investigate the effects of chemical fertilizer and vermicompost on the growth, herb production, nutrient absorption, soil fertility, and oil quality of rosemary. As compared to the control (no fertilizer), the application of vermicompost (8 t ha−1) + fertilizer nitrogen, phosphorus, and potassium (150:25:25 kg ha−1) produced the highest herbage and oil yield of rosemary among the seven treatments. It was also found to be comparable to applying NPK fertilizer at twice the rate. Post-harvest soil treated with vermicompost alone showed higher levels of available nitrogen and phosphorus (44).

A study examined the relative effects of chemical fertilizers, vermicompost, and food waste compost (FOWC) on red radish development. The average fresh weight of the 25% FOWC treatment was comparatively high, but the average fresh weight of the 50% mixed compost treatment was much lower. The data illustrates the potential efficacy of distinct food waste treatments in stimulating plant development. Specifically, 25% FOWC and 50% vermicompost have significant potential to enhance agricultural yields (45). The study supported the use of FOWC and vermicompost as sustainable and ecologically acceptable substitutes for chemical fertilizers, finding that they greatly increased plant growth. The current research highlighted how crucial it is to choose the right kinds of fertilizer and concentrations to increase agricultural output and environmental sustainability.

The impact of varying amounts of vermicompost combined with NPK on the chemical and physical characteristics of cowpea (Vigna unguiculata) and soil was assessed. The soil composition of the trial area was a sandy loam with 62.65% sand, 21.09% silt, and 16.26% clay, ordered in accordance with Inceptisols. The bean plants received three treatments: chemical fertilizer, vermicompost. Vermicompost and its combination with a small amount of chemical fertilizer were the most effective treatments in terms of their impact on the physical and chemical qualities of the soil (46).

Conclusion:

Proficiency has been conclusively demonstrated through research that earthworms and their excrement (ver-mincast) or even bodily fluids (vermiwash) have extraordinary potential for protecting and promoting crop growth. They may also serve as the primary "driving force" in sustainable food production, preserving the health and fertility of the soil and potentially eliminating the need for agrochemicals altogether or only requiring them as a "helping hand" (47). Sufficient nutrient availability is essential for healthy plant development and growth. By adding vermicompost, one may improve soil fertility, preserve moisture, add necessary nutrients in balanced amounts, and reduce pollution in the environment. Furthermore, in a variety of vegetable crops, vermicompost encourages greater plant height, blooming, fruiting, pod development, and leaf growth. It is important to provide farmers with guidance on vermicomposting and the proper application of vermicompost through the coordination of diverse training and extension initiatives. It is necessary to create creative and practical agricultural initiatives to support and encourage organic farming among farmers. They must be informed about the vermicomposting procedure and the appropriate amounts of vermicompost to use in agricultural areas to get the greatest outcomes.

Conflict of interest: NIL

Funding: NIL

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