A Review of Bokashi: Exploring Effects and Benefits as a Fertilizer

Abstract

This research paper provides a concise overview of the existing literature and scientific experiments pertaining to the effects and benefits of bokashi, with a particular emphasis on its role as a fertilizer and waste management technique. Acknowledging that the paper represents a limited examination of the extensive resources available on this topic, it aims to shed light on the potential advantages of utilizing bokashi for organic waste management and its effectiveness as a nutrient-rich soil amendment. The review delves into the underlying principles of bokashi, highlighting its microbial-driven fermentation process, and its ability to effectively break down organic matter while preserving essential nutrients. Furthermore, it explores the impact of bokashi on soil health, nutrient enrichment, and its potential as a sustainable fertilizer. The paper synthesizes current research to demonstrate the benefits of bokashi, such as improved plant growth, enhanced nutrient availability, and reduced reliance on synthetic fertilizers. By emphasizing the fertilizer aspect, this overview serves as a valuable resource for individuals seeking to understand the potential benefits of bokashi in an agricultural context. However, it is important to note that further research is needed to fully explore the existing literature.

Overview of the Bokashi Method

Communities across Europe face a significant challenge in effectively managing food waste, encompassing its treatment, disposal, and recycling. Studies indicate that approximately one-third to half of the world's food production is lost or wasted. The characteristics of food waste (FW) can vary depending on dietary and cultural habits, as well as economic factors, resulting in diverse physio-chemical properties. However, FW generally exhibits features such as relatively high solids content (around 20%), high carbohydrate content with low cellulose and lignin, and high protein (15-25%) and lipid (13-30%) content. Consequently, FW possesses a relatively low carbon-to-nitrogen (C:N) ratio compared to other organic substrates. Additionally, FW presents high concentrations of macroelements (e.g., P, K, Ca, or Mg) and relatively low levels of trace elements (e.g., Fe, Se, Ni, or Mo). While FW serves as a suitable substrate for anaerobic processes, challenges such as the low C:N ratio and deficiency in trace elements need to be addressed [1, 2].

Under the assumption of preserving nutritional quality through proper collection routines, bokashi fermentation of food waste with effective microorganisms (EM) represents a biological treatment approach that stabilizes bio-waste and generates a nutrient-rich fertilizer, promoting growth in field- and greenhouse-based food production systems. Bokashi fermentation offers a potential alternative to traditional composting of food waste (including secondary residues from industrial processes) by facilitating soil quality and plant production while reducing greenhouse gas emissions. The versatility of anaerobic fermentation allows for the treatment of diverse substrates, making it particularly suitable for FW management. In essence, the Bokashi substrate, comprised of various organic materials, is inoculated with a mixture of beneficial microbes that thrive in anaerobic and acidic environments. After a fermentation period as short as 10 to 20 days, two fractions - solid and liquid, known as "Bokashi tea" - can be collected separately from the bioreactor or combined for use as a semi-liquid fertilizer [1].

EM consists of mixed cultures of beneficial and naturally occurring microorganisms, serving as inoculants to enhance microbial diversity in soils and plants. The EM concept involves inoculating substrates with the aim of shifting the microbial balance and creating an improved microbiome that supports enhanced productivity. EM formulations contain up to 80 different species from five primary groups of microorganisms, including lactic acid bacteria (e.g., Lactobacillus plantarum, L. casei, L. fermentum, L. salivarius, L. delbrueckii), yeasts (Saccharomyces cerevisiae), photosynthetic bacteria (e.g., Rhodobacter sphaeroides, R. capsulatus, Rhodopseudomonas palustris), actinomycetes, and mold fungi. Aside from boosting food production, the EM microbes present in Bokashi starters, particularly lactic acid bacteria (LAB), purple non-sulfur bacteria (PNSB), and yeasts, can contribute to various beneficial environmental functions, such as the breakdown of harmful chemicals and the immobilization of heavy metals [1, 3-6].

Effects of Bokashi on Plant Yield and Quality

Research indicates that the application of effective microorganisms in conjunction with organic matter is crucial. These microorganisms can be administered in liquid form or combined with nutrient-rich organic matter to create fermented compost known as "Bokashi" in Japanese. The advantages of employing EM alongside organic matter lie in the ability of EM to ferment organic substances, thereby releasing nutrients and nutrient-rich organic acids that can be utilized by plants. Crop plants can also be directly treated with EM, with studies demonstrating enhanced physiological parameters, such as photosynthesis, leading to increased crop yields, which is an essential factor in organic farming [1, 7]. A meta-analysis supports the notion that EM inoculation boosts crop yield and growth [8]. Improved plant nutrition likely plays a significant role in these yield increases. The combined application of organic material and EM, either separately or as EM Bokashi fermentate, proves most advantageous in enhancing crop yield. Research indicates that EM Bokashi inoculation and fertilization result in significantly greater yield increases compared to other growth promoters [1, 8-9]. The mechanisms underlying these increased crop yields and quality, mediated by EM Bokashi, are diverse and not yet fully understood. Enhanced plant stimulation likely stems from three primary effects of the EM microbiome: (i) biofertilization, (ii) biocontrol, and (iii) biostimulation. As organic fertilizers, the accelerated decomposition of organic compounds into plant-available nutrients likely contributes to the increased productivity observed in crops treated with EM-inoculated organic matter compared to composts [1].

Further studies have explored the effects of Bokashi technology on plant health and crop yield. For instance, a study [6] found that the application of effective microorganisms significantly increased the yield of bean plants, even when cultivated in poor, sandy soil, demonstrating promising potential as a biostimulant. These findings align with previous studies cited by the authors. EM treatment has been shown to alleviate salinity stress by modifying various physiological processes associated with stress tolerance. Another study [10] reported that the application of plant-based Bokashi, derived from "Gamal" and "Komba-Komba" leaves, significantly enhanced the growth and yield of maize. At 14 days after planting (DAP), the Bokashi treatment increased plant height by 53%, plant diameter by 131%, and leaf number by 92% compared to the control group. Overall, the application of organic materials improved organic carbon levels, total nitrogen content, as well as the availability of phosphorus and potassium [10].

In summary, the application of effective microorganisms combined with organic matter, particularly through Bokashi fermentation, offers significant benefits for enhancing plant yield and growth. Studies have demonstrated that EM inoculation stimulates physiological processes in plants, such as photosynthesis, leading to increased crop yields. The combined application of organic material and EM, whether in liquid form or as Bokashi fermentate, proves to be more effective in enhancing crop productivity compared to other growth promoters. Additionally, the diverse effects of the EM microbiome, including biofertilization, biocontrol, and biostimulation, contribute to improved plant stimulation. Further research has shown that Bokashi technology can positively impact plant health and yield, even under challenging soil conditions, with increased growth and productivity observed in various crops. These findings highlight the potential of Bokashi in sustainable agriculture and its role in optimizing plant nutrition and performance.

Effects of Bokashi on the Soil Quality

The bokashi technology serves as a valuable resource for revitalizing and enhancing soil quality. When compared to regular compost, Bokashi offers distinct advantages. Most notably, Bokashi retains a significant portion of organic carbon (instead of losing it as CO_2), allowing for its sequestration within the soil [1]. Moreover, Bokashi fermentate maintains a higher carbon-to-nitrogen ratio, which stimulates microbial activity. The rate of mineralization in Bokashi, as in compost, depends on the C:N ratio [11]. Consequently, Bokashi promotes the activity of microorganisms, meso- and macro-fauna, leading to increased abundance and stability of soil aggregates [12]. This, in turn, enhances soil drainage and aeration, particularly in heavy soils. In coarse soils, the organic matter content improves water-holding capacity [1]. Research further supports the positive impact of Bokashi on soil fertility. Studies have demonstrated its effectiveness in enhancing soil chemical properties and fertility, especially in marginal soil conditions [3, 13]. For instance, Bokashi derived from burned rice husk and bokashi sago dregs has been found to increase soybean production, making it a recommended soil amendment for traditional farmers cultivating plants in marginal farmland [13]. Additionally, the efficient utilization of organic waste and Fermented Bokashi Compost (FBC) has been explored, showing enhanced soil chemical properties, increased nitrogen concentration, and accelerated organic matter degradation, leading to readily available net nitrogen [14]. Furthermore, the addition of bokashi from water hyacinths has been shown to improve soil conditions for the growth and production of soybean, corn, and rice in dryland soil [15].

Overall, the use of effective microorganisms in Bokashi contributes to the stabilization of soil organic matter [16-18]. This, coupled with its role as an organic fertilizer, explains the increased productivity observed in crops treated with Bokashi and other EM-inoculated organic matter compared to traditional compost. The rapid decomposition of organic compounds into plant-available nutrients plays a significant role in this phenomenon [1]. Moreover, research indicates that EM-treated organic matter contains significantly lower levels of heavy metal ions compared to standard compost derived from the same materials. The formation of immobile complexes of heavy metals within EM-treated organic matter ensures their harmless impact on plants and the environment [19, 20].

To conclude, the application of bokashi offers several benefits for soil quality. Compared to regular compost, bokashi retains a larger amount of organic carbon, which can be sequestered in the soil instead of being lost as CO_2. It also stimulates microbial activity and increases the stability and abundance of soil aggregates. Bokashi has been shown to enhance soil fertility, especially in marginal soil conditions, leading to improved crop production. Additionally, bokashi helps in the degradation of organic matter, resulting in readily available net nitrogen. The use of effective microorganisms in bokashi contributes to the stabilization of soil organic matter and reduces the presence of harmful heavy metal ions. Overall, bokashi plays a significant role in optimizing soil health, increasing nutrient availability, and reducing reliance on synthetic fertilizers.

Effects of Bokashi on the Soil Suppressiveness and Pesticide Degradation

Recent studies have shed light on the significant role of beneficial microbial soil communities in enhancing resistance to pathogens, a phenomenon referred to as 'soil suppressiveness' [21, 22]. Furthermore, a separate study [23] emphasized the importance of microbiome-mediated positive effects in stimulating both direct and indirect plant defenses, functioning as biological control agents (BCA). Among the mechanisms identified, lactic acid bacteria, for example, act as BCA through multiple means: (i) the production of antimicrobial compounds, reactive oxygen species [24], and bacteriocins [25], (ii) the exclusion of pathogens by actively colonizing plant tissues before they can establish themselves, and (iii) the modification of the plant's immune response [26]. In relation to these findings, it has been observed by [27] that Bokashi, either alone or in combination with effective microorganisms (EM), effectively reduced the incidence of soft rot disease in lettuce and cabbage. Another study [28] concluded that EM-treated plants exhibited a decrease in the number of tomato fruits damaged by blossom-end rot. Additionally, [29] and [30] reported positive outcomes, suggesting that the incorporation of Bokashi amendments contributed to a reduction in disease incidence in tomato plants. Moreover, a study [31] discovered that the application of EM to the soil contributed to the inhibition of fungal pathogen infestation on pea plants.

The presence of effective microorganisms (EM) in the soil has also shown promise in reducing the reliance on chemical plant protection agents and promoting pesticide degradation, as demonstrated by a comprehensive study [32]. In the realm of natural and organic agriculture, microorganisms have been employed as biological alternatives to pesticides, effectively protecting plants against harmful chemical residues [33]. Numerous authors have highlighted the significant role of microorganisms in the degradation of pesticide-active substances [34-36]. Microorganisms play a crucial part in the bioremediation of pesticides, offering a cost-effective approach to removing pollutants from the environment. During biodegradation processes, microorganisms transform pesticides into non-toxic metabolites that can be utilized in their metabolic activities. Enzymes, such as hydrolases, peroxidases, and oxygenases, play a pivotal role in facilitating these biochemical transformations [37, 38].

The efficiency of the degradation process is influenced by various environmental factors, including soil temperature, pH, humidity, and composition. Optimal conditions can enhance the biodegradation of pesticides, leading to the formation of harmless byproducts and positively impacting soil fertility in agricultural systems [39, 40]. Understanding the fate and dissipation of persistent contaminants in soil is of utmost importance for safeguarding both the environment and human health. These pollutants have the potential to leach into surface and groundwater sources, as well as accumulate in food products, posing a threat to consumers. Thus, it is crucial to develop safe and effective methods for soil remediation and environmental protection. Effective microorganisms are widely recognized as potent agents for biodegradation, capable of accelerating the dissipation of various chemical pollutants and revitalizing soil health [32].

To conclude, the final part of the paper explores the effects of bokashi technology on soil suppressiveness and pesticide degradation. Soil suppressiveness refers to the ability of beneficial microbial communities in the soil to enhance resistance to pathogens. Bokashi has been found to reduce the incidence of diseases such as soft rot and blossom-end rot in plants, likely due to the presence of effective microorganisms that act as biological control agents. Studies have shown that the application of bokashi amendments can contribute to a reduction in disease incidence in various crops. Furthermore, bokashi technology has demonstrated promise in reducing the reliance on chemical pesticides and promoting pesticide degradation. Microorganisms play a crucial role in the biodegradation of pesticides, transforming them into non-toxic metabolites through enzymatic processes. The efficient degradation of pesticides by microorganisms is influenced by environmental factors such as temperature, pH, and humidity. Optimal conditions can enhance the biodegradation process and positively impact soil fertility. Overall, bokashi technology offers potential benefits for soil suppressiveness and pesticide degradation. The presence of effective microorganisms in bokashi enhances soil health and reduces the need for synthetic pesticides, contributing to sustainable agriculture practices. By understanding the role of bokashi in these aspects, farmers and researchers can explore its potential for improving soil quality and reducing environmental impacts.

Conclusion

In conclusion, this research paper has provided a comprehensive review of the effects and benefits of bokashi as a fertilizer and waste management technique. Bokashi, with its microbial-driven fermentation process, has shown remarkable potential in breaking down organic matter while preserving essential nutrients. By synthesizing current research, this review has highlighted the benefits of bokashi, such as improved plant growth, enhanced nutrient availability, and reduced reliance on synthetic fertilizers.

The paper also discussed the impact of bokashi on soil health and fertility. Bokashi retains a significant portion of organic carbon, sequestering it within the soil and promoting microbial activity. It enhances the stability and abundance of soil aggregates, improving soil drainage and aeration. Bokashi has been found to enhance soil fertility, particularly in marginal soil conditions, leading to increased crop production. Additionally, the application of bokashi has demonstrated positive effects on soil suppressiveness, reducing the incidence of plant diseases.

Furthermore, bokashi technology has shown promise in pesticide degradation, offering a biological alternative to chemical plant protection agents. Effective microorganisms present in bokashi contribute to the biodegradation of pesticides, transforming them into harmless byproducts. This has significant implications for soil remediation and environmental protection.

Overall, bokashi stands out as a product with multiple benefits. Its ability to efficiently break down organic matter, improve soil health, enhance plant growth, and promote pesticide degradation makes it a valuable tool in sustainable agriculture. By utilizing bokashi, farmers and gardeners can reduce their reliance on synthetic fertilizers and chemical pesticides, contributing to a more environmentally friendly and sustainable approach to food production. Although further research is needed to fully explore the potential of bokashi, the existing literature highlights its promising role in optimizing plant nutrition, soil quality, and overall agricultural sustainability.

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