



Mini Review

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Co-existence of Pesticides and Fertilizers in Agricultural Soil Environment



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Abstract

Pesticides and fertilizers are of utmost importance in suppression of pests and meeting food requirements. However, the excessive and inefficient use has ended up in severe environmental damage, in which soil health has intensively witnessed most critical part of harmful problems. Exposure of pesticides and fertilizers adversely affects soil nutrient content, enzyme activities, predominant non-target organisms, structural and functional biodiversity of microbial populations. It has been observed that the adsorption-desorption, leaching and degradation behaviors of pesticides can be modified in response to fertilizers, which regulate microorganisms for assimilated pollutants. Application of optically pure, bio-based pesticides and fertilizers for soil amendment is a sustainable and low cost option to avoid combined contamination in the soil environment. The practices of organic wastes as cost-effective biochar loaded fertilizers can also further achieve a double win targets in the formation of green production mode for pesticides and fertilizers. Additionally, more studies are needed to help identify opportunities for new agro-ecosystem.

Keywords: Pesticides; Fertilizers; Soil pollution; Ecotoxicological effects; Remediation strategy

Introduction

Pesticides and fertilizers become an indispensable part of modern agriculture used to control pests and improve crop yields. Feeding the population in China requires increasing agricultural production. Therefore, growing demand is mainly dependent upon heavy input of pesticides and fertilizers [1]. Soil is a large pool of microorganisms and plays important roles in the emergence or spread of pesticides and fertilizers [2]. Soil pesticide pollution categorized into insecticides, fungicides, and herbicides mainly comes from the process of controlling pests and diseases [3]. Agricultural soils are particularly at risk since 30–50% of applied pesticides may transfer to soil surface and deep positions [4]. Furthermore, excessive use of pesticides will affect the soil quality and functions [5]. Currently, the common fertilizers include chemical and organic types. Although fertilizers can improve soil nutrition [6], heavy metals, micro plastics and other pollutants, instead, are also introduced into farmland soil, thereby modifying soil properties [7,8], functions, biodiversity, etc. [9,10] and ultimately threatening human health through the food chain. In order to ensure agricultural production and human health, the Ministry of Agriculture in China has put forward the

strategic policies for zero growth, amount reduction and efficiency increase of pesticides and fertilizers.

Impact of Fertilizers on Pesticides Fate in Soil

The persistence of pesticides in soil is generally altered by fertilizers. The complex varieties and interactions between pesticides and fertilizers bring new challenges and different results of fate for pesticides. Study discovered that organic fertilizers may reduce the mobility of pesticides [11], so as to further interfering the breakdown of pesticides [12]. Some results have suggested that pesticides existed longer in soil amended by urea and organic fertilizers [13,14]. On the contrary, the favored pesticide degraders by urea, organic manure and compost amendments induced the enhanced pesticide degradation in soil [15-20]. The effect of fertilizers on the biodegradation rate of pesticides works in connect with the structure of pesticides. For instance, organic fertilizers decelerated biotic degradation of $-C\equiv N-$ containing pesticides, in contrast, increased the relative abundance of $-NO_2-$ containing pesticide degraders [21]. The leaching and adsorption-desorption determine the pesticide availability for main transfer processes in soil and water body. Positive interactions of fertilizers

towards adsorption-desorption [22,23] and leaching [24,25] of pesticides were also presented with different characteristics in soil. The changes of adsorption-desorption and leaching may attribute to interactions between pesticides and dissolved organic matter.

Combined Ecotoxicological Effects of Soil Pesticides and Fertilizers

Response of soil property indicators to pesticides and fertilizers

Pesticides and fertilizers are correlated with biotransformation and nutrient dynamics of soil organic compounds. Soil health is presumed as subsets of ecosystem health and decided by physical (texture, water holding capacity, soil aggregate dynamics, bulk density, porosity, compaction, infiltration rate), chemical (pH, nutrient availability, salinity, soil organic matter), and biological (C: N ratio, microbial activity, microflora, enzymatic activity, soil respiration) properties [26]. It was reported that the application of pesticides and fertilizers caused soil acidification [27]. The nitrogen cycle was disturbed by pesticides, chemical fertilizers and manure [28]. Organic fertilizers applied after fumigation improved fertility, activated soil catalase, sucrase activities and promoted the abundance of soil beneficial microorganisms [29]. Owing to the fact that structure of soil microbial communities exhibited obvious variance treated by fertilizers and pesticides [30], genes probably significantly decreased in soils [31]. From this point of view, the change of soil functions will further affect pesticide degradation. Lower mineral adsorption, more active microorganisms and nutrients for microbial growth positively promote the degradation of pesticides [32].

Availability of pesticides and fertilizers to soil non-target organisms

Earthworms are common indicators for pollution in a wide range of soils and may represent 60%~80% of the total biomass. Pesticides usually lead to reduced body weight and morphological changes in surviving earthworms. It is demonstrated that lower application rates of long-term organic amendment may conspicuously shape or benefit earthworm gut functional structures and microbial diversity. Biological availability and toxicity of pesticides in soils are affected by the nature of binding to organic matter types [33], which can be adjusted by fertilizers. Previous research has confirmed that mixture of pesticides and phosphate fertilizers negatively caused significant changes in defense system of earthworm *Lumbricus terrestris* [34]. Accordingly, low toxic pesticides and organic biological fertilizers are more friendly for earthworms.

Countermeasures for Soil Pesticides and Fertilizers Pollution

New pesticides and fertilizers system

The soil quality was improved by partly organic fertilizer

replacement and pesticide reduction (green manure, organic substitution, biological pesticides, etc.) [35,36]. A large number of studies have shown that the effective combination of organic and chemical fertilizers not only provides appropriate nutrients, ensures crop yield, but also further reduces the negative impact on soil health [37-41]. Biopesticides, which are derived from natural sources (fungi, bacteria, plants, animals and minerals) for pest management are potential alternative to develop with high efficiency and low toxicity [42]. In addition, developing effective monomers of pesticides involved chiral characteristics is also an important method for pesticide reduction [43,44].

Remediation of pesticides pollution by biofertilizers

Biochar is extensively studied as an ideal adsorbent for the removal of pesticides and verified to be a promising carrier for fertilizers [45]. Research has shown that the bio-organic fertilizers developed by agricultural solid wastes well removed pesticide in soil [46]. It can be seen that the application of biochar as a consequence could simultaneously eliminate the combined pollution from fertilizers and pesticides.

Conclusion

Concern about agricultural soil health is linked to both pesticide and fertilizer pollution. Adhering to the strategic policy of reducing amount and increasing efficiency of pesticide with fertilizer can contribute immediately and long-term maintenance to agricultural productivity and profitability. It has advantages of harnessing the power of biology to work with the interaction characteristics between pesticides and fertilizers, evaluate their combined adverse effects on soil properties and organisms. We still need to further deepen the understanding of ecological principles from expanding the pesticide and fertilizer types, samples, time length, and crop systems. Starting from the full construction of environmental behavior and toxicological evaluation mechanism, reduction and bioremediation are approaches to design and adopt driven by development of biological pesticides, fertilizers and biochar materials. The pesticide and fertilizer co-pollution deserves attention and comprehensive study on advancing soil ecological health, crop yield and green agriculture.

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