

白蚁活动与土壤环境之间的相互作用

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摘 要 白蚁是自然生态系统中的一个重要物种, 白蚁活动与其环境土壤之间具有多种多样的相互作用。本文是对有关研究报道的初步总结, 内容包括蚁穴及其环境特征、白蚁活动对土壤性质的影响、土壤环境对白蚁活动的影响以及研究展望 4 个部分。

关键词 白蚁活动; 土壤环境; 相互作用

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白蚁对人类健康及生活和工作环境带来的严重危害已众所周知。但作为生态系统中的一个重要物种, 白蚁又在自然界的分解过程和矿化过程中扮演着重要的角色。白蚁的取食、建穴和排泄等生命活动以不同的方式和不同程度上影响着土壤环境^[1, 2]。有研究认为白蚁对农业生态系统中许多重要过程的影响可能是利大于弊^[3]。

与国外相比, 国内在白蚁与土壤环境关系的研究方面基本还处于空白状态。本文作为对国外近年来有关研究报道的初步总结, 内容包括蚁穴及其环境特征、白蚁活动对土壤性质的影响、土壤环境对白蚁活动的影响以及研究展望, 希望国内能够对这一研究领域有所关注。

1 蚁穴及其环境的特征

白蚁利用自己的唾液或粪便混合泥土和木屑, 在地下、地表或植被上建造蚁穴^[2, 4~6]。蚁穴的形状、尺度及内部结构多种多样。形状上如亚球状、教堂状和蘑菇状或圆锥状。尺度上有的蚁穴直径仅几厘米, 廊道仅长几米, 有的蚁穴则直径可达数米, 廊道长达 50m 以上。蚁穴的重量一般介于 $10^2 \sim 10^5$ kg/hm²。

1.1 蚁穴内部的环境特征

蚁穴内部的环境特征主要为温度、湿度和 CO₂ 浓度 3 个方面。结构简单的蚁穴其内部小气候类与环境类似, 但结构复杂的蚁穴则可调节温度和湿度。蚁穴内部温度较为稳定, 但湿度变化较大^[2, 7, 8]。白蚁可以通过在低荫处建穴, 建造厚的蚁穴外壁、在四周储存草料或预留空间, 通过蚁穴上的各类气孔和裂隙通风等方式调节蚁穴内部的温度。保持蚁穴

内部一定湿度对表皮柔软持水能力差的白蚁至关重要, 白蚁可以通过挖掘通达水源的廊道, 利用建穴材料吸水保湿, 利用代谢水等方式以保持必需的湿度。有的白蚁还可将穴建在树木上以防止过多水分的侵袭^[2]。白蚁活动可产生 CO₂, 但其可以忍受较高的 CO₂ 浓度。蚁穴内部的 CO₂ 浓度可在 0.6% ~ 20%, 但一般多介于 1% ~ 4%。白蚁可以通过空气流动而调节蚁穴内部的 CO₂ 浓度^[2]。

1.2 蚁穴的理化特征

蚁穴与环境土壤的理化性质之间存在一定的差异。蚁穴具有相对较高的 pH、粘粒及粉沙粒、有机 C、全 N 和有机质、P 素、阳离子含量及盐基饱和度和、孔隙度, 强抗穿透力, 低磷酸酶活性等特点^[5, 6~25]。某些蚁穴相对富含 Fe, Al, Na, P, Cu, Zn, Co, Ba, Cr, Li, Ni, Be, V, Y, Ce 和 La 元素, 因此可作为探矿指示物^[26]。

2 白蚁活动对土壤性质的影响

2.1 有利影响

白蚁活动对分解植物残体至关重要^[2, 27]。通过分解植物残体, 白蚁活动促进了植物残体的 N 素释放、有机质分解以及矿物质和养分循环^[28~32]。增加土壤有机质, 特别是稳定的腐殖酸, 有利于土壤结构的稳定和土壤肥力的提高^[33, 34]。白蚁在建造蚁穴过程中翻覆土壤物质, 导致养分在土壤剖面中重新分布^[35, 36], 通过挖洞钻孔增加土壤的孔隙度, 提高土壤的导水率和渗透率^[37~39], 改善土壤的物理性质, 提高土壤养分含量和作物产量^[40~44]。白蚁活动还可以刺激 CO₂ 产生和土壤有机 N 矿化^[45], 加剧土壤中的反硝化作用^[46], 通过体内固氮酶活动为其

栖息地贡献 N 素^[47, 48]。

蚁穴在受到腐蚀、被废弃或重建过程中, 会使土壤重新分布, 引起土壤剖面及土壤性质发生一系列的变化^[2, 18, 24, 29]。虽然白蚁的群居性限制了其活动范围, 但数量众多、分布广泛的蚁穴仍可大面积地改变了水文学和土壤学过程^[49]。

2.2 不利影响

除危害作物外, 白蚁对土壤的不利影响主要表现在两个方面: 一是蚁穴土壤(由于紧实等特点)不利于作物的生长^[50]; 二是白蚁与土壤争夺植被残体, 影响作物生长的养分供应^[51], 还可能引起土壤流失^[52]。

3 土壤环境对白蚁活动的影响

3.1 气候因素

温度和湿度是影响白蚁活动的两个重要的气候因素, 可以通过纬度、海拔和季节反映。白蚁主要生活在北纬 45°~ 南纬 45° 地区中海拔 3000m 以下的地区^[2], 白蚁活动旱季强于雨季^[53, 54]。澳大利亚西部小麦种植带白蚁活动在秋季和春季为最强^[55]。美国佛吉尼亚潮汐林地中白蚁体内固氮酶活性在秋季和春季较高, 在冬季和夏季则较低^[56]。

3.2 土地和土壤性质

白蚁对环境具有一定的选择性。沙漠地区及干旱和半干旱地区, 白蚁一般选择条件相对较好的灌木和草丛作为生活场所^[57, 58]。白蚁也偏向选择人为干扰小地点, 如天然林区^[59]、休闲或免耕土壤^[41, 60~63]、适度放牧区^[40, 64]。白蚁活动也可能因土壤类型和土壤性质的不同而存在一定的差异。退化的淋溶土和非退化淋溶土中白蚁更易选择前者^[65]。土粒粒径小、容重低、孔隙度高、湿度低的土壤, 白蚁活动强烈^[66, 67]。有作物残体覆盖或施用有机物料的土壤, 白蚁活动相对较强^[42~44, 60, 68, 69]。灌溉可制约白蚁活动^[70]。白蚁活动与土壤的有机质及 P 素高低之间的关系尚无定论^[40, 54, 73]。

3.3 植物类型与作物覆盖

植被类型及用于覆盖土壤的作物类型也会影响白蚁活动^[14]。印度 Karnataka 地区落叶林区主要是食菌白蚁, 而常绿林则为食菌白蚁和食木白蚁^[74]。作物覆盖一般可以激发土壤中白蚁的活动^[42~44]。但不同的作物种类因其 N 素和木质素含量的差异, 对土壤中白蚁活动的刺激可能有所不同^[75]。有研究认为白蚁偏向摄食 N 和 P 含量高的植物残体^[76]。

3.4 其它因素

作物生育期和土壤生物之间的竞争关系也会对白蚁活动产生一定的影响。Reddy 等的研究表明, 白蚁危害在玉米生育后期逐渐明显并加重^[77]。土壤中其它类型的小节肢动物对植物残体的争夺也可能削弱白蚁的活动^[78]。某些真菌对白蚁活动具有一定的抑制作用^[79]。

4 研究展望

白蚁种类及活动特性多种多样, 与土壤环境之间的相互作用及其机理也错综复杂。迄今国外的有关研究可以分为两大主要方面: 研究对象为森林、草原(或牧场)的一般偏重白蚁活动与环境之间的相互关系; 而研究对象是耕作土壤的则偏重于白蚁防治。

许多基础方面的研究尚处于发现问题和现象阶段, 如何从机理上科学地解释已发现的问题和现象还有待于进行更深入、更复杂和更系统的工作。旱地土壤中白蚁活动研究的多, 而水田土壤则很少。如何利用白蚁对植物和土壤的选择性以及其它有益生物对白蚁的抑制作用等无害措施控制和降低白蚁危害也是一个具有积极意义的研究方面。反之, 如何“扬长避短”和“化害为益”, 有选择地利用白蚁活动来改善耕作土壤的理化性质, 或者有选择地利用特定土壤类型培育“食用”白蚁等同样值得关注。另外, 白蚁的固 N 行为对 N 素循环的影响以及白蚁活动对区域和全球 C 库平衡和温室效应的影响, 也是潜在的研究热点。

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INTERACTIONS BETWEEN TERMITE ACTIVITIES AND SOIL ENVIRONMENTS

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Abstract Termite is an important species in the natural ecosystem. Its activities interact with soil environment in many ways. A review of the literature available is presented consisting of four parts, i.e. termite mounds and their environmental features, impact of termite activities on soil properties, impact of soil environment on termite activities, and outlook of the termite research.

Key words Termite activities, Soil environment, Interaction