菌渣还田对中国北方农牧交错带农田土壤生境的影响

赵飞燕[1] 侍世玲[1] 孟芮冰[1] 马泽[1] 蒙仲举[1*]

（1. 内蒙古农业大学沙漠治理学院 呼和浩特 010010）

摘　要:【目的】农牧交错带是我国北方重要的生态屏障和粮食安全屏障。由于中国北方地区由于频繁的地表扰动导致土壤肥力较低，因此存在活跃土壤性质的潜力。探究菌渣还田对土壤性质的影响，有助于在生产力较弱的地区减少化肥的使用，最终实现绿色农业。【方法】试验材料为废弃菌渣和经过发酵有机肥料并达到完全分解的状态（鸡粪，牛粪）。在还田之前，发酵后的真菌残留物被装进便于运输的包装袋（每包 30 个）。2019 年春至期间，废弃真菌残留物均匀分布在土壤表面。还使用旋转耕作机将肥料涂在 0-20 厘米之间的层上。连续三年后，这些田地种植了当地适应的裸燕麦选取 6 个浓度的菌渣进行预实验。采用不同浓度的 0 - 30 cm 土层土壤样品(10 cm 单位)，比较土壤性质的差异。【结果】菌渣还田对土壤容重、孔隙度和含水率有积极影响。不同还田浓度下土壤容重变化范围为 1.12 - 1.59 g / cm3。向田间添加菌渣对土壤参数(SOM 和 AP)的增加效果更好，且这种特征效应随着还田浓度的增加而持续。但土壤孔隙度变化不明显。随着还田浓度的增加，细菌和放线菌的数量先增加后减少，真菌表现出持续增加。除放线菌数量外，真菌残留量仅在 0-10 厘米和 10-20 厘米层中显著增加。选择土壤脲酶(SU)，土壤蔗糖酶(SS)和土壤碱性磷酸酶(SAP)来表征菌渣还田对土壤酶的影响。土壤脲酶和土壤蔗糖酶的活性随土壤深度的增加而降低，但土壤碱性磷酸酶随深度呈现先降低后升高的趋势。在真菌残留处理的土壤中，土壤酶活性优于 CK，SU，SS 和 SAP 活性分别提高到 4%-49%，3%-63%和 3%-77%。【结论】菌渣还田改善了土壤物理结构，提高了通气性和透水性，且这种作用随着菌渣浓度的增加而增强。菌渣还田对孔隙度的影响相对较小，仅增加了 12.12 %。向田间添加菌渣对提高土壤参数(SOM 和 AP)效果较好，且这种效果随着还田浓度的增加而增强。与 CK 相比，细菌、真菌和放线菌数量分别增加了 1.94 倍、1.46 倍和 1.71 倍。在 R11 条件下，土壤脲酶活性最高。不同土层蔗糖酶活性变化趋势不一致。AK 与其他因子相关性较强，微生物与酶活性相关性较强($P < 0.01$)。

关键词：菌渣还田；农牧交错带；土壤性质；土壤肥力

Soil habitats are affected by fungal waste recycling on farmland in agro-pastoral ecotone in northern China

Abstract: 【Objective】As part of the ecological barrier and food security, the agro-pastoral ecotone is vital in the northern China. Since soil fertility in northern China is low due to frequent surface disturbances, there is the potential to actively.soil properties. Exploring the effect of fungal residue return on soil properties will help reduce the fertilizer used in areas with weak productivity and ultimately achieve green agriculture. 【Method】The test materials were waste fungal residue and organic fertilizer(chicken manure, cow manure) that were fermented and completely decomposed. Before returning to the field, the fermented fungal residue was packed into packaging bags for easy transportation (30 per package). The waste fungal residue was evenly distributed on the soil surface during the spring tilling period in 2019. A rotary cultivator was also used to apply the fertilizer to the layer between 0-20 cm. After three consecutive years, the fields were planted with locally adapted naked oat. The experiment was based on a long-term dry farmland observation station. Six concentrations of fungal residue were selected for the pre-experiment. We used different concentrations of soil samples from the 0-30 cm soil layer (10 cm unit) to compare

the differences in soil properties. 【Result】Fungal residue return ositively impacted soil bulk density, porosity, and moisture content. The range of soil bulk density under different returning concentrations was 1.12-1.59g/cm3. Adding fungal residue to the field was better in increasing soil parameters (SOM, and AP), and this characteristic effect continued as the return concentration increased. However, changes in the soil porosity were not apparent. With the increase in return concentration, the amount of bacteria and actinomycetes first increased and then decreased, and fungi showed a continuous increased. Except for the number of actinomycetes fungal residue return significantly increased microbe numbers only in the 0-10 cm and 10-20 cm layers. Soil urease(SU), soil sucrase(SS), and soil alkaline phosphatase(SAP) were selected to characterize the effect of fungal residue inputs on soil enzymes. The activities of soil urease and soil sucrase decreased with the increasing soil depth, but soil alkaline phosphatase showed a trend of first decreasing and then increasing with depth. In the soils under fungal residue treatment, the soil enzyme activities were superior to those of CK, and the activities of SU, SS, and SAP, increased to 4%-49%, 3%-63%, and 3%-77%, respectively.【Conclusion】Fungal residue return improved soil physical structure, and increased aeration, and water permeability, and this effect increased with increasing residue concentration. The effect of mushroom residue return to the field on porosity was relatively small, which only increased by 12.12 %. Addition of fungal residue to the field was better in increasing soil parameters (SOM and AP), and this effect increased as the return concentration increased. Compared with CK, the number of bacterial, fungi, and actinomycetes increased by 1.94 times, 1.46 times, and 1.71 times, respectively. Under the conditions of R11, the soil urease activity was the highest. The trend of sucrase activity in the different soil layers was inconsistent. AK was strongly correlated with the other factors, and the microorganisms and enzyme activiies were strongly associated($P<0.01$).

Keywords: Fungus return; Agro-pastoral ecotone; Soil properties; Soil fertility