



## Rapid restoration of spoil ground along expressways through a combination of vetiver grass cultivation and fertilization

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Soil degradation of the spoil ground generated during the construction of expressways is a serious concern, and the ecological environment of the mound created by the unplanned piling of abandoned soil is poor. Revegetation could quickly and efficiently restore the ecological environment of the spoil ground. This study aimed to explore the direct and indirect effects of different fertilization treatments on the remediation of spoil ground soil using vetiver grass, and determine the most appropriate combination of fertilizers to help repair the ecological environment of the spoil ground. To study the changes in the physicochemical properties, enzyme activity, microorganisms in rhizosphere soil, and plant characteristics of vetiver grass, 12 treatments were set up, including no fertilization (CK), a single application of nitrogen fertilizer (N1:150 kg/ha, N2:300 kg/ha, and N3:450 kg/ha), a single application of phosphorus fertilizer (P1:350 kg/ha and P2:700 kg/ha), and a chemical fertilizer combination (NP: N1P1, N2P1, N3P1, N1P2, N2P2, N3P2). Compared with CK, combined nitrogen and phosphorus fertilization improved the physicochemical properties, enzyme activities, microbial diversity of rhizosphere soil and the plant traits, more significantly than the treatment with nitrogen or phosphorus fertilization alone. Path analysis showed significant differences between the direct and indirect paths of plant characteristics under the N, P, and NP treatments. NP treatment was more helpful in improving the soil environment of spoil ground, because NP treatment had a higher path coefficient for plant traits (NP (0.807) > N (0.703) > P (-0.993)) and enzyme activities (NP (0.897) > P (0.767) > N (0.373)). N2P2 had the highest comprehensive score (34), indicating that N2P2 could be used as an effective fertilizer combination. These results indicate that the benefits of appropriate cultivation and fertilization practices to help restore degraded soil. Combined fertilization treatment (NP) improved the path coefficient of soil physicochemical properties to plant traits and soil enzyme activities, and thus better restored the habitats of spoil ground.