

Responses of soil absolute and specific enzyme activities to different vegetation restoration modes in burnt site

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Abstract: **Objective** The aim of this study was to investigate the effects of different vegetation restoration modes on soil absolute enzyme activities (per unit of soil mass) and specific enzyme activities (per unit of microbial biomass carbon or per unit of organic carbon) in the burnt site, and their relationship with soil organic carbon(SOC), mean weight diameter (MWD) and microbial biomass carbon (MBC). **Method** In 2012, a forest fire broke out in the pure ponytail pine plantation forest in Laifu Town, Gao County, Yibin City, Sichuan Province, and the above-ground vegetation was severely burned and the land was exposed, forming a fire burnt site. In the same year, the project team selected four 1a-growing valuable native tree species, namely, *Pinus massoniana* (PM), *Sassafras tzumu* (ST), *Cinnamomum longepaniculatum* (CL) and *Phoebe zhennan* (PZ), to carry out vegetation restoration work. Sample plots that were not restored after the fire were used as the control (CK). In July 2022, in each standard sample plot, five sampling points were randomly laid out in the shape of 'S', and the soil was collected from 0-20cm depth after removing the litter on the surface. Fresh soil samples were dried at 4°C to 'optimum' moisture (approximately 15% gravimetric soil water content). Then, individual soil clods were gently broken apart along the natural naturally formed cracks and sieved through an 8 mm mesh. Following that, soil aggregates were fractionated using a sieving a soil aggregate analyzer. Finally, four different aggregates were obtained: >2, 2-0.25 and <0.25 mm. Then, each soil aggregate fraction was weighed and divided into two parts. One part was used to determine the soil enzyme activity and microbial biomass, the other part was naturally air-dried for the determination of relevant physicochemical properties. **Result** Compared to the control, all vegetation restoration models increased the activities of invertase, urase and acid phosphatase and GMea of the soil aggregates. Values for URE and ACP were significantly higher in CL than those in the rest of the restoration models ($P < 0.05$). Except for urease, aggregate size had a significant effect on soil enzyme activities ($P < 0.05$). In addition, soil absolute enzymatic activities and GMea showed significant positive correlations with MWD, SOC and MBC for all the vegetation restoration modes. There were significant ($P < 0.001$) effects of different vegetation restoration on soil specific enzyme activity per unit of MBC. Except for INV/MBC, vegetation restoration negatively affected on URE/MBC, ACP/MBC of the soil aggregates, and the specific enzyme activities of URE and ACP per unit of MBC was the lowest in CL mode. Aggregate size had a significant effect on soil specific enzyme activities except for URE/MBC ($P < 0.05$). INV/MBC was higher in 1-2 mm and 0.25-1 mm aggregates than that in the remaining two aggregate fractions. In addition, ACP/MBC was strongly and negatively correlated with MWD, SOC and MBC in any of the vegetation restoration models, and URE/MBC was significantly and negatively correlated with MBC values ($P < 0.05$). Changes in the soil specific enzyme activities per unit of SOC were similar to the variations in specific enzyme activity per unit of MBC. INV/SOC and ACP/SOC were highly significant under different vegetation restoration ($P < 0.01$). INV/SOC was lowest in the un-restored samples. However, URE/SOC and ACP/SOC had the lowest enzyme activities per unit of SOC in the CL model. ACP/MBC were the highest of all soil aggregates in ST. Aggregate size had a significant effect on INV/SOC ($P < 0.05$). Among them, the INV per unit of SOC in 1-2 mm and 0.25-1 mm aggregates was higher than the remaining two aggregate sizes. However, there were no significant effects of different treatments and soil aggregate size on URE/SOC. URE/SOC was significantly negatively correlated with MWD and SOC. And the current study further showed that soil enzyme activities per SOC were all strongly and negatively correlated with SOC values. **Conclusion** Our results demonstrated that vegetation restoration affected soil enzyme activities in burned areas, but the direction and magnitude of the effect depended on whether the activities were expressed as absolute or specific activities of soil enzymes. Although vegetation restoration increased the absolute activity of soil enzymes, the specific enzyme activity varied with enzyme species and tree species. In general, the specific enzymatic activities could reflect changes in plant cover and composition, soil SOC, MBC, and microbial community metabolic status, providing useful indicators of the effectiveness of vegetation restoration. Thus, sustainable

afforestation should be developed to increase soil enzyme activity and improve soil quality in the study area. Thus, sustainable land abandonment should be developed to maximize soil enzyme activity and increase soil quality in the studied area. In addition, compared to other vegetation restoration models, the CL restoration mode had higher soil nutrient, GMea and MBC contents. Thus, the use of the unique local ecological and economic species of *Cinnamomum longepaniculatum* for vegetation restoration is even more effective.

Keywords: vegetation restoration; burned areas; soil enzyme activity; geometric mean of enzyme activity; soil aggregates.