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Resistance and resilience of soil biodiversity after tree logging: case studies in rubber plantation in Ivory Coast

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Abstract

After a Rubber plantation cycle (25 to 40 years), the greatest risk of soil degradation occurred during the replanting period which extends from the clear cutting of an old plantation to the planting of young rubber trees. During this period, the soil is subject to numerous disturbances mainly related to (1) the opening up of the environment following clear cutting (2) the export of organic matter with machines and (3) the practice of deep subsoiling by heavy machinery. These practices may affect directly or indirectly biodiversity and the delivery of soil functions (Missanjo and Kamanga-Thole 2014).

To mitigate soil degradation after one or more plantation cycles, some agricultural practices are commonly used, such as the implementation of a cover crop in the inter-rows at planting (Gao et al. 2017; Liu et al. 2018). Another alternative to restore soil functions is to leave the logging residues (i.e. trunk, branches, leaves and roots of the logged plantation) on the plot, given the high amount of carbon and nutrients accumulated in the tree at the clear-cut stage (Perron et al. 2021). The positive impact of crop residues has been demonstrated on soil fauna resilience (Lassauce et al. 2012; Carron et al. 2015), soil organic carbon and nutrients (Alam et al. 2018). However, so far, this agroecological practice has never been tested in rubber plantations and the effect of the restitution of logging residues on soil functioning has never been addressed.

We set up a field experiment after logging of the previous old RP in two industrial rubber plantations in Ivory Coast with contrasting soil types. In each RP, different type of logging residues and legume were added after clear cutting to determine their respective impact on the resilience of soil biodiversity. We hypothesized that (i) the input of logging residues and legumes after a clear-cutting will promote the resilience of soil biodiversity (microbial, nematode and macrofauna) (ii) soil types will affect the level of resistance and resilience of the soil biodiversity.

In both sites, we observed a significant loss of soil biodiversity, 6 months after clear-cutting and land preparation. The negative impact of mechanical disturbance on the dynamics of soil biodiversity has been revealed by lower abundance, richness, beta diversity, ecological indexes and co-occurrence networks. For example, soil macrofauna density significantly dropped by 36.04

and 93.65% at sandy and clay site respectively. Macrofauna diversity decreased significantly by 60.6% at sandy site and 91.39% at clay site. Practices with logging residues contributed to higher resilience of macrofauna density (~ 360% in clay site and 300% in sandy site) and diversity (134–154% in clay site and 58-73% in sandy site) than practice without residues (75–97% in clay site and 35-38% in sandy site). The application of logging residues and legume was the most efficient practice to promote soil biodiversity and to mitigate the negative impact of clear-cutting in rubber monocultures after a 40 years' rotation.

Key words: Soil biodiversity, Rubber plantation, Restoration, Logging residues