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Fragmentation, fiber separation, decomposition, and nutrient release of secondary-forest biomass, mechanically chopped-and-mulched, and cassava production in the Amazon

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ABSTRACT

No-tillage planting in mechanically-chopped secondary-forest seeks to replace slash-and-burning agriculture. We evaluated the effect of horizontal (HC) and vertical (VC) chopping-and-mulching mechanisms on vegetation fragmentation and decomposition rate and nutrient release from chopped residue, and on cassava production in eastern Amazon. Chopped-and-mulched residue was classified into four residue-size (Fs_1 = 1–7, Fs_2 = 7–25, Fs_3 = 25–35, and Fs_4 = >35 mm) and six residue-type (with husk/bark – WB, partially chopped – PC, compact – C, partially shredded into fibers – PS, completely shredded into fibers – CS, and formless residue – F) classes. In litter-bags, residual dry matter (DM) was determined at five different days after chopping-and-mulching and residue distribution on soil surface (DAD), whereas release of N, P, K, Ca, and Mg was evaluated at four days. Residues-size and -type classes showed similar decomposition behavior, with a reduction of approximately 60% of initial DM at 90 DAD. Nevertheless, reduction in DM was slow, where 52 days are necessary for half of labile residue to be decomposed, with part of labile and recalcitrant residue remaining on soil surface. DM and nutrients in residue reduced over time. DM was 25% for residues-size classes for HC, 20% for VC, and 26% for residue-type classes, on average, at 300 DAD. Nutrients remaining in residues at 300 DAD were 26% and 27% of N, 26% and 22% of P, 29% and 22% of K, 16% and 15% of Ca, and 17% and 23% of Mg, respectively for HC and VC. Release of nutrients was, generally, greater for smaller residue-size classes, similar between chopping-and-mulching mechanisms, and did not affect cassava yield.

1. Introduction

Biomass management in open areas is done mainly by means of prescribed fires. However, fire was shown to produce degradation of soils and vegetation (Guénon et al., 2013) and intense soil and water erosion losses (Cerdà, 1998a,b,b). The effect of fire disappear only some years after the fire (Cerdà and Lasanta, 2005; Lasanta and Cerdà, 2005), and mulching is a good strategy to reduce soil and water losses after the fire (Prats et al., 2013). The use of other managements is necessary and within them the use of chipped biomass is being found useful, such as Lee et al. (2013) found in road embankments, Jiménez et al., (2013) in afforested land, García-Orenes et al. (2012) and Tejada and Benítez (2014) on agriculture land, or Milder et al. (2012) and Mukhopadhyay and Maiti (2014).

Soil management systems traditionally used in eastern Amazon consist of slashing-and-burning of secondary-forest that develops in fallows period between agricultural crops, with further soil turnover for planting (Denich et al., 2005; Béliveau et al., 2009). Soil surface remains more exposed to raindrop impact, which leads to soil degradation and greater soil and water losses through surface runoff (Farella et al., 2001; Davidson et al., 2008). There is also greater risk of accidental fires (Ruivo et al., 2007), greenhouse gas emissions (Davidson et al., 2008), loss of nutrients through leaching (Sommer et al., 2004; Béliveau et al., 2009), soil organic

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matter oxidation (Davidson et al., 2008), and consequent reduction in cation exchange capacity (CEC) (Farella et al., 2007; Béliveau et al., 2009; Adeniyi 2010). Further, after fires there is dispersion of clays with reduction in aggregate stability and increase in soil bulk density (Braz et al., 2013), increase in soil surface temperature (Ferreira et al., 2002), and greater moisture variations from increased solar radiation on soil surface layer (Cochrane and Sanchez, 1982).

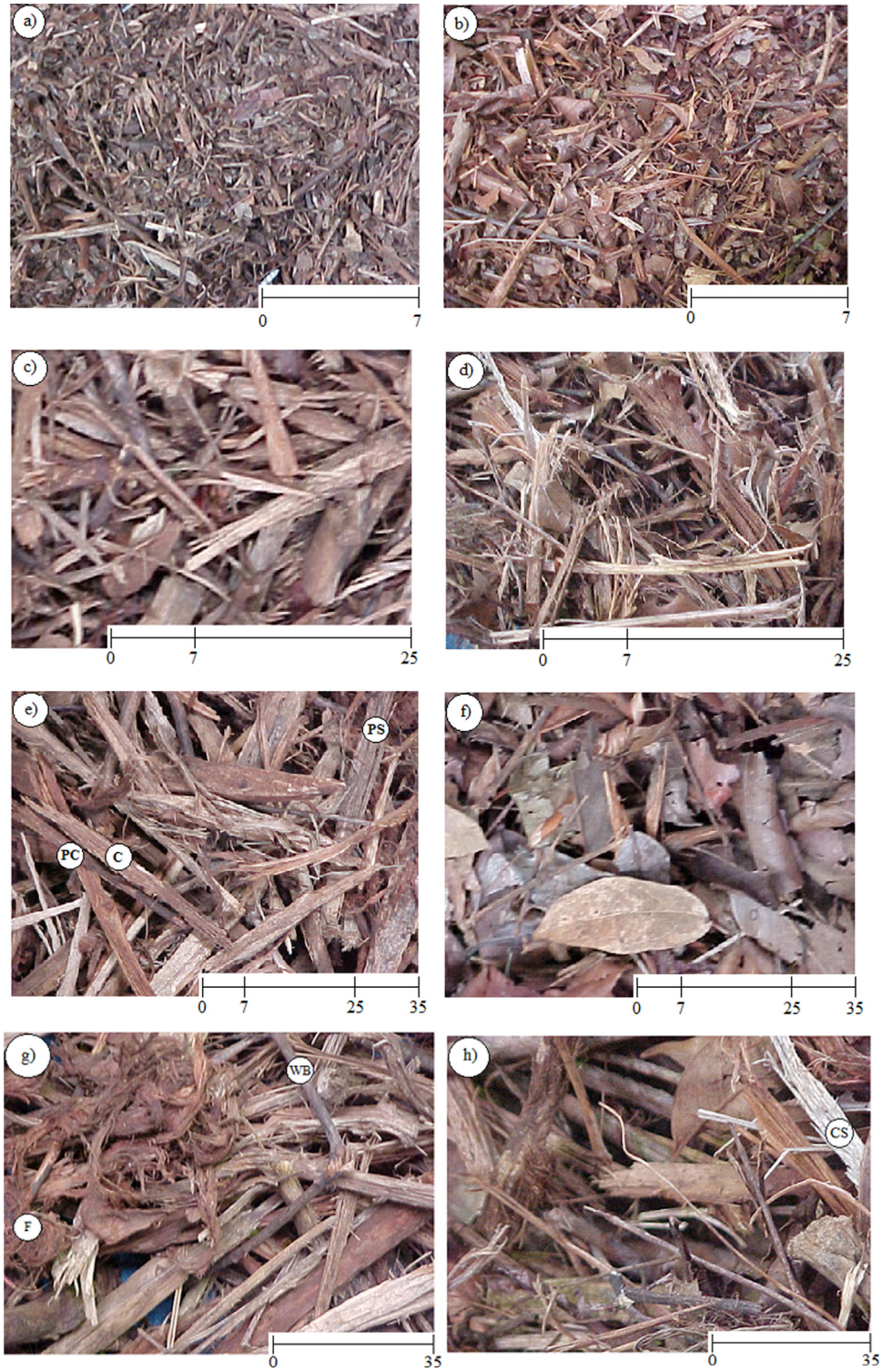

Fig. 1. Residue-size classes from chopping-and-mulching of secondary-forest vegetation through horizontal (a, c, e, g) and vertical (b, d, f, h) rotor mechanisms. Photos by C.M. P. Bervald.
Fs_1 = 1–7 mm (a and b), Fs_2 = 7–25 mm (c and d), Fs_3 = 25–35 mm (e and f), and Fs_4 = >35 mm (g and h).
Numbers on scale bars are in mm.
White bullets with capital letters in 'e', 'f' and 'g' represent residue-type classes, from chopping-and-mulching of secondary-forest vegetation in both rotor mechanisms: WB – with bark, PC – partially chopped, C – compact, PS – partially shredded, CS – completely shredded, and F – formless.