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Application of wood ash containing charcoal to intensive forest plantations in humid temperate regions

Agustin Merino, Beatriz Omil, Martin Santalla, Fernando Solla-Gullon, Cesar Perez-Cruzado, Federico Sanchez-Rodriguez, Nieves Barros, and Roque Rodriguez-Soalleiro

Santiago de Compostela, Escuela Politécnica Superior, Lugo, Spain (agustin.merino@usc.es)

Wood ash, generated in biomass in power plants, is a suitable material for improving forest nutritional status and growth. This is especially important in intensive forest systems in humid temperate regions, where the use of intensive management can lead to to the loss of nutrients and SOM. Two types of wood ash are produced in biomass power plants: fly ash and bottom ash. The benefits of fly wood ash as a forest fertilizer have been widely studied, especially in Scandinavian countries. However, the use of bottom wood ash has not yet been tested.
Unlike fly ash, bottom ash or mixed wood ash (MWA) is less reactive because many of the elements are included in partially burnt organic compounds. Elements are therefore released more slowly and the fertilizing effects of MWA may be maintained for relatively long periods. In addition, MWA contains large amounts of charcoal (in some cases more than 40 %). Charcoal improves the physical, chemical and biological properties of soil (mycorrhizal associations, higher microbial activity), and thus also provides beneficial effects to plants. In addition, charcoal is relatively recalcitrant and can therefore be used as a long-term sink for atmospheric CO2.

This presentation includes the main results of three experiments carried out in plantations of Pinus radiata. These experiments were carried out at different stages of the rotation: a) at establishment, b) in young plantations (before canopy closure, at 13 years) and c) in mature plantations (before the second thinning, at 25 years). The MWA was incorporated into the soil at establishment. In the other cases, MWA was spread on the surface. In all cases, conservative doses of MWA, 5-12 Mg ha-1, were used. In young and mature plantations, the MWA was also complemented with mineral P fertilizer.

Application of MWA led to moderate increases in soil pH, lower than recorded after application of fly wood ash, and to moderate increases in Ca, Mg, K in soil and needles. In young and mature plantations, improvements in P only occurred after addition of the highest doses of MWA or when MWA was added along with mineral fertilizer.
The results of vector analysis clearly showed that application of MWA can improve the nutritional status of young plantations, in terms of P and Mg, which are the most limiting nutrients. In mature plantations, monitoring of nutrients returned by litterfall confirmed the higher supplies of P, Mg, Ca and K.

The high C:N ratio and the presence of charcoal led to lower soil N mineralization rates and lower mineral N in the soil (laboratory measurements and field incubations). The lower availability of N was detected in the composition of litterfall. Since these plantations are not limited by N, this did not affect tree growth.

The study of C cycling was carried out by microbial analysis, litterbag experiments and analysis of soil organic compounds. The data did not reveal any alterations in litter decomposition rates. However, the application of NMR and DSC techniques to mineral soil samples led to important increases in different compounds in the SOM, ranging from labile carbohydrates to aliphatic groups and more recalcitrant molecules.

Significant increases in tree growth were detected at all three stages in the plantations. The best responses were observed with doses higher than 10 Mg MWA ha-1 and when MWA was complemented with mineral P fertilizer. The application after a thinning improved the conditions for spreading and produced a synergy with the effect of density reduction, reducing significantly the rotation age, which made the application economically profitable.