Tropentag, September 16-18, 2026, hybrid conference

"Towards multi-functional agro-ecosystems
promoting climate resilient futures"

Agronomic practices and sugarcane biomass burning affect PM2.5 emission and soil fertility in Thailand

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Abstract

Agronomic practices such as land preparation, harvesting, disease management, and crop residue management are among the leading causes of dust emissions in crop production systems. In Thailand, crop biomass burning has become a common practice, especially for sugarcane, rice, and maize. Pre- and post-harvest biomass burning during the dry season is a significant source of air pollution at the farm level, particularly particulate matter 2.5 (PM2.5). In addition, biomass burning reduces the return of organic carbon and nitrogen to the soil, thereby affecting soil fertility in agricultural lands. So far, very few studies have examined the effects of sugarcane farm management practices on PM2.5 emissions and the impact of sugarcane biomass burning on mineral nutrient composition in Thailand.

The research was conducted in Kamphaeng Phet Province, the largest sugarcane-growing in northern Thailand. In addition to secondary PM2.5 data, field measurement campaigns were carried out on sugarcane farms during the dry season (i.e., the harvesting period). Controlled in- field biomass-burning experiments were conducted using biomass samples from both organic and conventional farms, as well as from five commercial cultivars. The mineral nutrient content of dry biomass and ash samples was analysed, and the C/N ratio was evaluated. A farmer survey was also conducted to identify key farm activities contributing to PM2.5 pollution, the drivers of biomass burning, and the associated impacts on farmers' health.

PM2.5 concentrations at the Kamphaeng Phet monitoring station reached 120 $\mu g\,m^{-3}$ during the 2023 dry season. However, in-field sugarcane residue-burning experiments showed PM2.5 concentrations exceeding 999 $\mu g\,m^{-3}$, while PM > 0.3 μm reached 60,000 $\mu g\,m^{-3}$. Interestingly, biomass from organic sugarcane farms (cultivar KK3) emitted less PM2.5 than biomass from conventional farms. Nutrient analysis indicated that organic sugarcane crop residues contained higher levels of nitrogen(5.5 $g\,kg^{-1}$), phosphorus(0.85 $g\,kg^{-1}$), and potassium(10 $g\,kg^{-1}$) than conventional residues. Moreover, nitrogen and carbon were lost during combustion. The farmer survey indicated that sugarcane smut disease control was the primary reason for biomass burning.

These findings reveal narrow policy incentives for unburned cane, yet redirecting subsidies to pest-reducing cycles and valorising lignin-rich residue can yield superior ecological and economic outcomes, guiding future long-term soil assessments.

Keywords: Agronomic practices, C/N ratio, crop residue management, farm-pollution, mineral nutrients, *Saccharum officinarum*

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