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

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Background

Sugarcane (*Saccharum officinarum*) is an important economic crop in Thailand. Sugarcane farming involves various intensive agronomic practices and produce huge amount of crop residues.

- Biomass management (with and without disease problem) is a major challenge for sugarcane production in Kamphaeng Phet province, Thailand. Farmers still practice open burning in fields for various crop residues management.
- Burning sugarcane residues helps farmers reduce harvesting and management costs. In consequence, it also contributes to local particulate matter (PM) pollution and affect farmers health itself.
- Alternative to burning is returning organic matter to the soil and improve soil fertility. Yet, such studies are very limited, especially sugarcane farming in Kamphaeng Phet province, which may support sustainable and long-term sugarcane cultivation in Thailand and beyond.

Therefore, we investigated:

i) What extent the agronomic practices and sugarcane biomass burning contribute to **PM2.5 emission**?

ii) How major sugarcane genotypes affect local particulate pollution or **soil fertility attributes** by **burning** or **straw-return** practices?

Agronomic practices

Fig. 1. Field preparation (A) and sugarcane planting (B). Machine harvesting of sugarcane and straw left unburned in the field (C). Manual harvesting and residues left unburned in the field (D).

Materials and methods

Sugarcane dry matter and ash samples collection, analysis:

- Five genotypes (one organic and five conventional farms) were grown in Kamphaeng Phet, Thailand. Khon Kaen 3 (KK3) was cultivated in both organic and conventional farms.
- Sugarcane dry matter burning experiment was done in field condition and collected ash. The mineral compositions in dry biomass and ash samples were analysed using Inductively Coupled Plasma (ICP) and CNS analysis.
- PM2.5 was recorded for agronomic practices such as tillage, planting and harvesting in field condition.

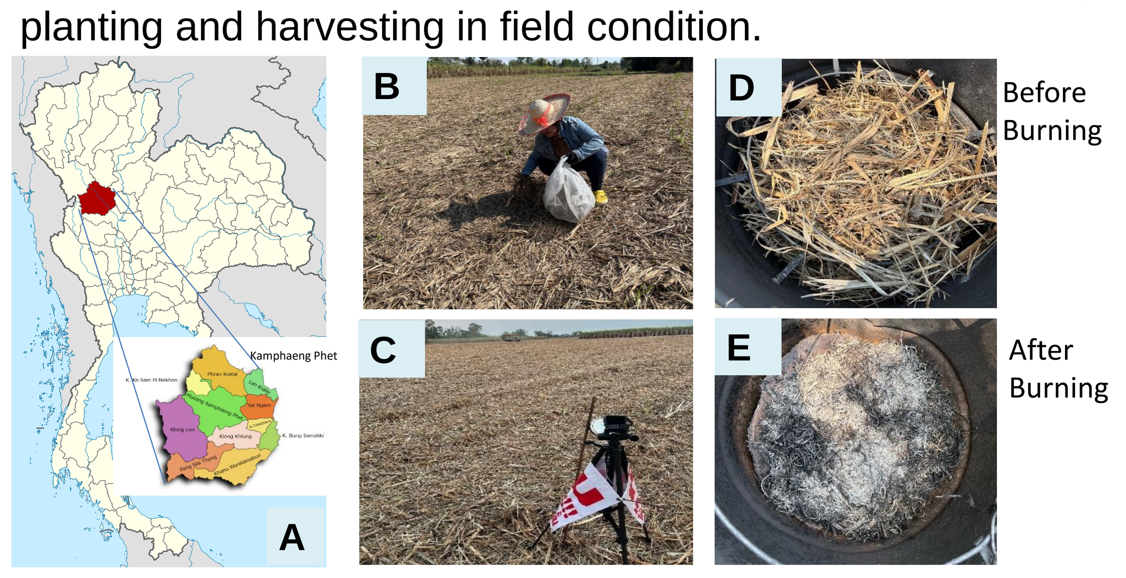

Fig. 2. Map of Kamphaeng Phet, Thailand and selected study sites (A), Sample collection from a organic farm (B), PM2.5 recoding at field during agronomy practices (C), In-situ controlled burning experiment: dry biomass (D) and ash (E).

Sugarcane agronomy practices

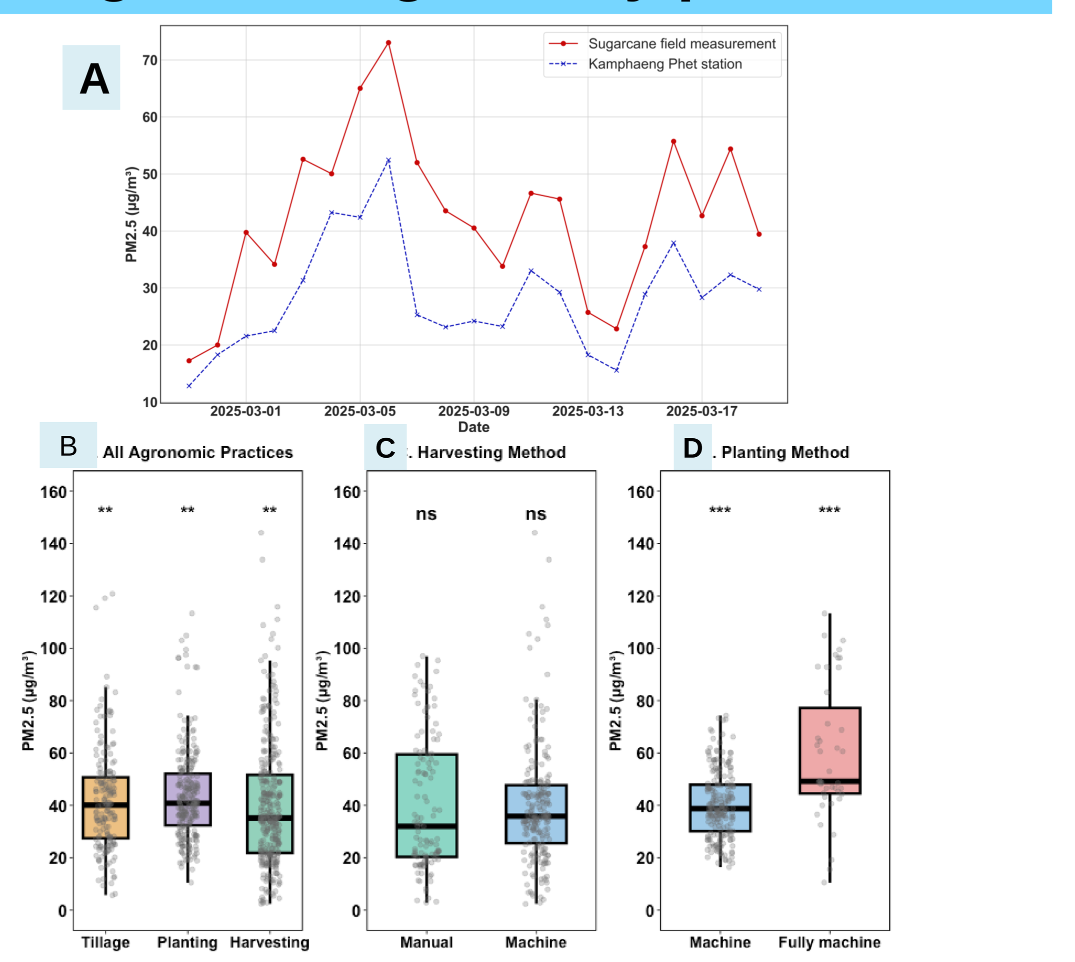

Fig. 4. PM2.5 comparison between Kamphaeng Phet station and sugarcane field measurement during soil preparation (tillage and planting) and harvesting (A). PM2.5 emission during agronomy practices (B), the sugarcane harvesting method (C), and sugarcane planting method (D). Statistic: Kruskal-Wallis (B), Mann-Whitney U test (C, D). PM2.5 unit is µg/m3. Significance levels: P < 0.001 (***), P < 0.01 (**), ns = non-significant.

Conclusions and Outlook

- Fully automated machine-planting method contributed more to the PM2.5 emission than combined (machine-field preparation with manual planting).
- Burning of organic sugarcane biomass was faster and emitted lesser particulate matters (PM2.5, PM > 0.3 µm) than conventional one (genotype KK3).
- PM2.5 pollution at on-farm measurements correlated with those from the monitoring station, but was higher, indicating as a local source of the pollution.
- C:N ratio was higher in conventional-sugarcane residues (dry mass, ash – cultivar KK3), whereas N-P-K content was relatively higher in organic dry mass.
- Straw-return and/or organic sugarcane farming practices help reduce PM2.5 emission and improve soil fertility attributes.

PM emission by biomass burning

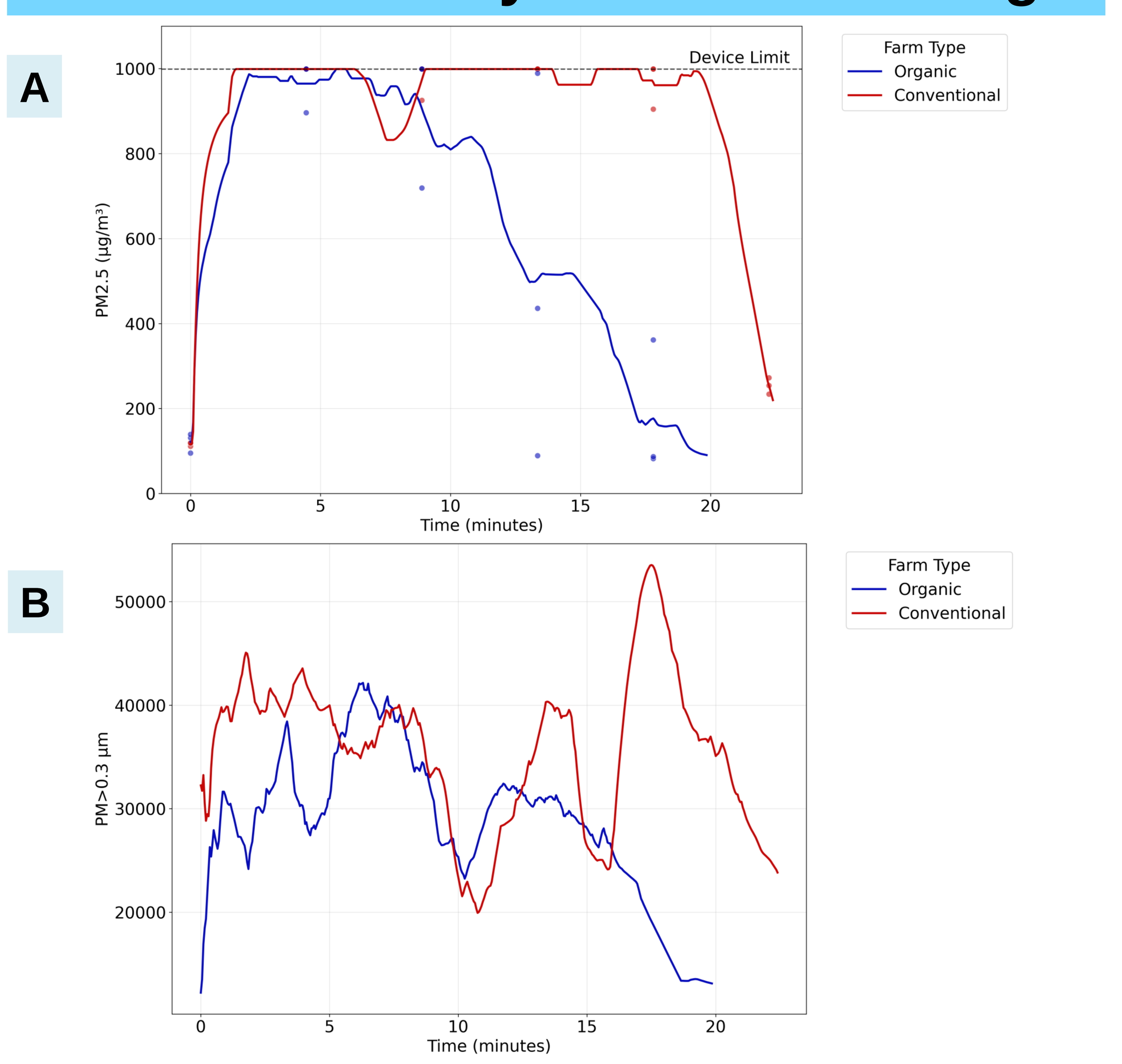

Fig. 3. Particulate matter (PM) emissions from in-field chimney experiments. PM2.5 is quantified as µg/m³, PM0.3 as no. of particles/m³. Comparing PM2.5 emission with KK3 organic vs conventional (A), and PM0.3 emission (B).

Mineral content in dry matter

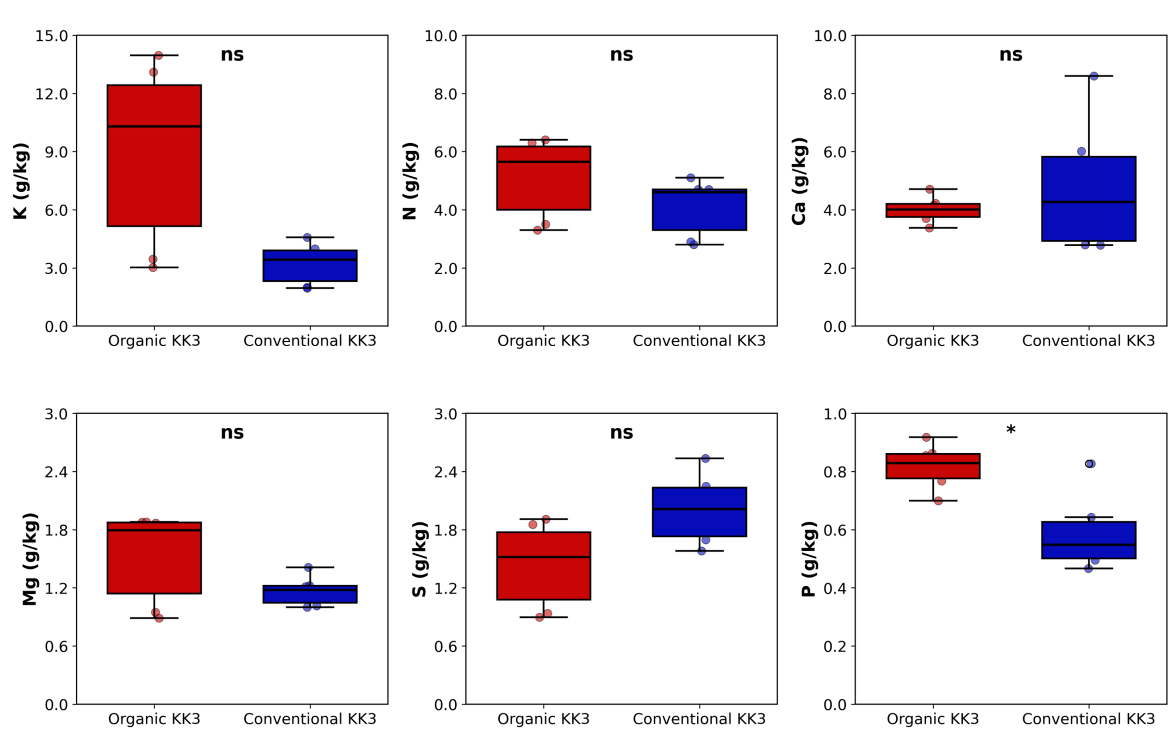

Fig. 5. Mineral elements content in sugarcane dry matter in KK3 genotypes. KK3 - organic farm type is red (n=6). KK3 from conventional farm type is blue (n=6). K, Ca, Mg, S, and P elements were quantified by ICP-OES method. Total N was quantified using CNS analyser. Non-parametric test by Mann-Whitney U-test. Significance levels: P < 0.05, ns = non-significant (P > 0.5).

Disease and Biomass management

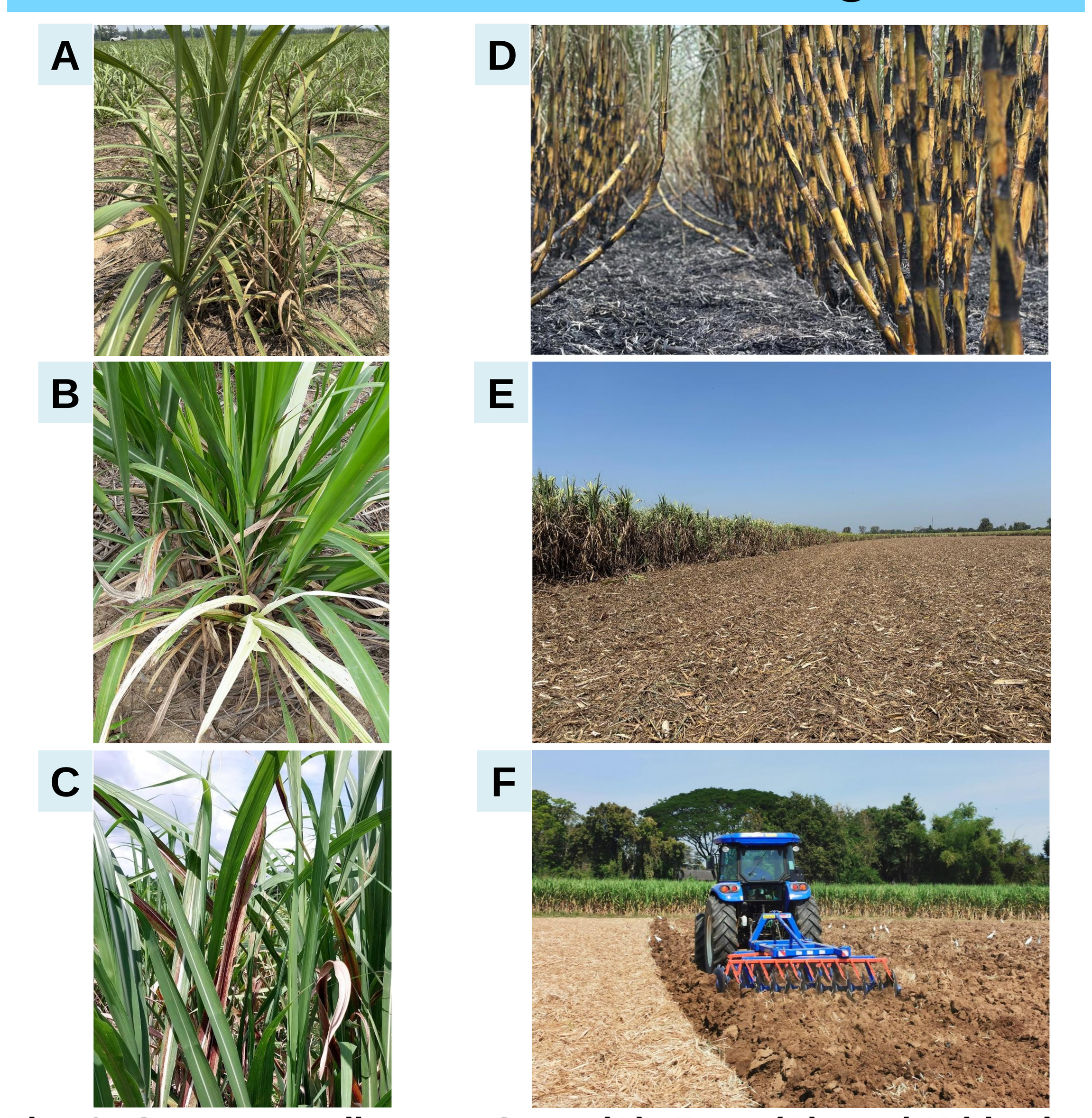

Fig. 6. Sugarcane disease :Smut (A), Rust (B), and White leaf disease (C). Ash after burning (D), left residues on the field without management (E), Plough dry matter back to soil (F).

Carbon and nitrogen ratio

Farm type	Genotypes	Dry Matter ± SD	Ash ± SD
Organic	KK3	85 ± 27	44 ± 18
Conventional	KK3	114 ± 34	63 ± 14
	TP6	99 ± 22	32 ± 2
	KPS01-12	71 ± 84	38 ± 5
	LK92-11	105 ± 14	38 ± 5
	CSB15144	117 ± 16	45 ± 19

Fig. 7. Carbon nitrogen ratio of sugarcane dry matter and ash content of selected genotypes (N=6). KK3 Ash (conventional) have 3 samples. KK3 and CSB cultivars have high C/N ratio in dry matter. KK3-organic cultivar have relatively lower C/N ratio in both dry matter and ash samples.

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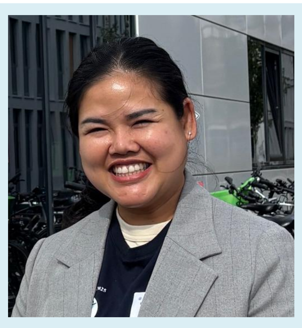

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