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Protocol for conducting combustion experiments to measure grass flammability

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BurnProtocol



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We use this protocol and it's working

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Abstract

Understanding how plant materials ignite and burn is essential for studying fire behaviour and vegetation flammability. This protocol presents a reproducible laboratory method for quantifying the combustion characteristics of grass samples under controlled conditions. Using a Bunsen burner and a metallic mesh container, the procedure standardises ignition and burning dynamics while enabling the measurement of core flammability metrics. Using minimal equipment, the method offers a simple, replicable, and scalable approach to compare the flammability of vegetation species.

Image Attribution

Figure 1: Experimental setup (left) and metallic mesh container used for grass combustion (right)

Figure 2: Grass samples placed within the metallic mesh container before combustion

Figure 3: Schematic diagram illustrating the calculation of dry weight at the time of the experiment

Materials

Setup

- Bunsen burner
- Metal grid to support samples
- Metal supports or holders
- Metal mesh container (10 × 10 × 40 cm)
- Non-reflective black tray
- Metal tray
- Aluminium foil
- Thermal camera (Optris Xi 400 or similar)
- Video camera (Sony HDR-CX405 or similar)
- Tripods for cameras

Field

- PEE including gloves, safety glasses, high visibility clothing, helmet
- Pruning shears
- Re-sealable plastic bags or containers
- Coolers

Other

- Oven
- Oven container
- Scale

Before start

1. Sample collection

Collect entire grass individuals in the field using gloves and pruning scissors if needed.

Place each sample in a sealed, clearly labelled container (plastic bag or pot).

Keep the containers in a cooler until arrival at the laboratory.

2. Sample preparation

Record the fresh weight of each sample.

Dry the samples in an oven at 40 °C for four days

Experimental setup

- 1 Place the metal grid on top of the supports (see Figure 1).

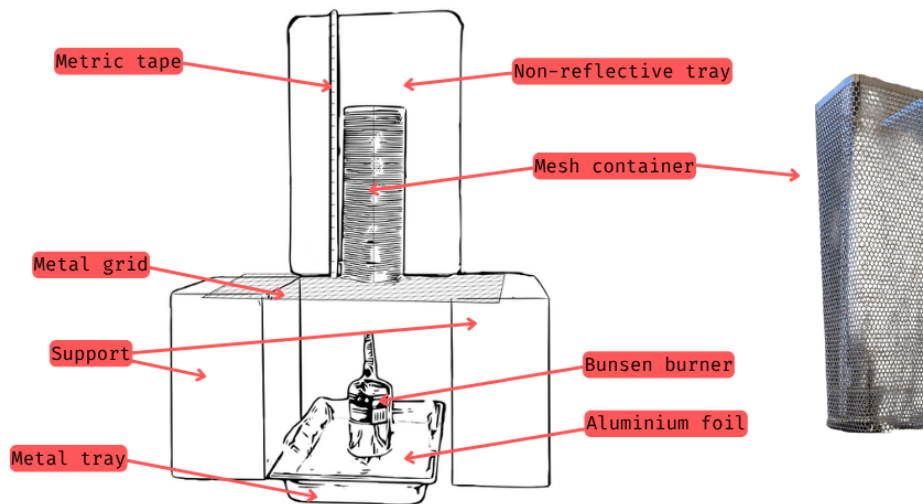


Figure 1: Experimental setup (left) and metallic mesh container used for grass combustion (right)

- 2 Position the Bunsen burner beneath the grid, ensuring the flame reaches the grid and is not affected by air currents. The distance between the burner and the grid should be approximately 10 cm.
- 3 Place a metallic tray lined with aluminium foil below the burner to collect ashes.
- 4 Position the non-reflective background tray behind the setup.
- 5 Set up the tripods holding the cameras at a distance of 2–3 m. Ensure the tray surface does not interfere with the thermal camera's field of view. Mark the tripod positions on the floor to allow precise repositioning if the setup is disassembled.
- 6 Thermal camera configuration:
 - 6.1 Connect the camera to the laptop and open the Optris PIX Connect Software.

- 6.2 Set the distance between the camera and the mesh.
- 6.3 Adjust the temperature range:
Tools > Configuration > Device range → 150–900 °C
Enable Extended setting for temperatures above 900 °C
- 6.4 Configure video recording:
Configuration > Recording > Video sequence
- 6.5 Define measurement areas:
Tools > Configuration > Measure area
Add a custom measurement box surrounding the mesh (set to Maximum mode).
Add a second area corresponding to the gas flame to serve as a control.

Protocol

- 7 Sample division.
Divide each sample into six parts. One part is retained as the reference subsample for FMC and dry weight determination (see Section *Calculating dry weight at the time of the experiment*). The remaining five parts serve as experimental replicates.
- 8 Preparing a replicate.
Select one replicate (1–3 g), record its experimental weight, compact it into a bundle, and insert it into the metallic mesh container (see Figure 2). This configuration ensures a critical fuel mass and structural arrangement necessary to sustain combustion. Other configurations or individual plants alone did not sustain burning. Each replicate is positioned at a consistent height using etched reference marks on the mesh cube as a guide.



Figure 2: Grass samples placed within the metallic mesh container before combustion

- 9 Experimental conditions.
To minimise environmental interference, turn off the air extractor and close all doors during the experiment. Open the gas valve and ignite the Bunsen burner. Adjust the gas flow until the flame reaches the grid level, ensuring consistent ignition conditions.
- 10 Ignition and combustion.
Start video and thermal recording.
Place the mesh containing the grass bundle on the grid. Maintain a consistent orientation across replicates.
The experiment begins when the mesh is placed on the grid ($t = 0$ s). The sample is ignited upright from the base, maximising heat transfer and promoting upward flame propagation.
Once ignition occurs, turn off the Bunsen burner. The time to ignition (TI) is recorded. Allow the sample to burn until complete flame extinction (flaming duration, FD). Stop recording.
- 11 Post-combustion processing.
Gently shake the grid to release ashes onto the aluminium foil covering the tray.
Temporarily remove the Bunsen burner.
Empty all remaining content from the mesh into the foil.
Record the final (ash) weight. Only after weighing the ashes, reopen the extractor and windows to ventilate the laboratory—ashes are highly volatile and may disperse if disturbed earlier.
Repeat the procedure from Step 8 for the remaining replicates.

Calculate the flammability metrics

- 12 Time to ignition (TI) is calculated as the time it takes for the sample to ignite after being placed above the flame. Flaming duration (FD) is the time from ignition until the flame is completely extinguished. These variables are derived from video recordings, which provide precise timestamps. To normalise for sample size, divide each time variable by the dry mass (see Section *Calculating dry weight at the time of the experiment*) to obtain the normalised time to ignition (NTI) and normalised flaming duration (NFD). Mass loss (ML) is calculated as the difference between the sample's initial and final weight, recorded directly during the experiment, while relative mass loss (RML) is calculated by dividing by the initial weight of the sample. Maximum temperature (MT) is defined as the highest temperature achieved during the combustion, and is recorded by the thermal camera as the highest pixel value within the flame area of the sample during combustion. The rate of temperature increase (RTI) is calculated as the derivative of the temperature curve at the initial phase of combustion, corresponding to the period of rapid heating.

Calculating dry weight at the time of the experiment

- 13 The dry weight of each replicate is calculated using its weight at essay and the FMC determined from the reference subsample (see Figure 3). It is assumed that all replicates share the same FMC as the reference subsample.

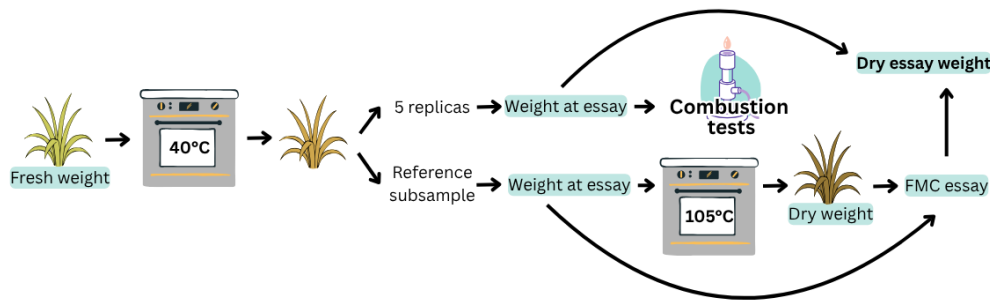


Figure 3: Schematic diagram illustrating the calculation of dry weight at the time of the experiment

- 13.1 Weigh the reference subsample.
- 13.2 Dry it at 105 °C for 24 hours.



- 13.3 Weigh again to obtain the dry weight.
- 13.4 Calculate FMC and compute the dry weight at the time of the experiment for each replicate using its initial weight and the reference FMC.

Protocol references

1. Jaureguiberry, P., Bertone, G. and Díaz, S. (2011) 'Device for the standard measurement of shoot flammability in the field: FLAMMABILITY MEASUREMENT IN THE FIELD', *Austral Ecology*, 36(7), pp. 821–829. Available at: <https://doi.org/10.1111/j.1442-9993.2010.02222.x>.
2. White, R.H. and Zipperer, W.C. (2010) 'Testing and classification of individual plants for fire behaviour: plant selection for the wildland–urban interface', *International Journal of Wildland Fire*, 19(2), pp. 213–227. Available at: <https://doi.org/10.1071/WF07128>.
3. Wyse, S.V. et al. (2016) 'A quantitative assessment of shoot flammability for 60 tree and shrub species supports rankings based on expert opinion', *International Journal of Wildland Fire*, 25(4), p. 466. Available at: <https://doi.org/10.1071/WF15047>.