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# Particle size, leaf pubescence and condition of humidity at leaf surfaces are key factors determining the retention of volcanic ash on crop foliage.

**Noa Ligot**[1], Benoît Pereira[1], Patrick Bogaert[1], Guillaume Lobet[2,3], and Pierre Delmelle[1]
[1]Earth and Life Institute, Environmental Sciences, UCLouvain, Louvain-la-Neuve, Belgium
[2]Earth and Life Institute, Agricultural Sciences, UCLouvain, Louvain-la-Neuve, Belgium
[3]Agrosphere Institute, IBG3, Forschungszentrum Jülich, Jülich, Germany

Volcanic ashfall negatively affects crops, causing major economic losses and jeopardising the livelihood of farmers in developing countries where agriculture is at volcanic risk. Ash on plant foliage reduces the amount of incident light, thereby limiting photosynthesis and plant yield. An excessive ash load may also result in mechanical plant damages, such as defoliation and breakage of the stem and twigs. Characterising crop vulnerability to ashfall is critical to conduct a comprehensive volcanic risk analysis. This is normally done by describing the relationship between the ash deposit thickness and the corresponding reduction in crop yield, i.e. a fragility function. However, ash depth measured on the ground surface is a crude proxy of ash retention on plant foliage as this metrics neglects other factors, such as ash particle size, leaf pubescence and condition of humidity at leaf surfaces, which are likely to influence the amount of ash that stays on leaves.

Here we report the results of greenhouse experiments in which we measured the percentage of leaf surface area covered by ash particles for one hairy leaf plant (tomato, Solanum lycopersicum L.) and one hairless leaf plant (chilli pepper, Capsicum annuum L.) exposed to simulated ashfalls. We tested six particle size ranges (≤ 90, 90-125, 125-250, 250-500, 500-1000, 1000-2000 µm) and two conditions of humidity at leaf surfaces, i.e. dry and wet. Each treatment consisted of 15 replicates. The tomato and chilli pepper plants exposed to ash were at the seven- and eight-leaf stage, respectively. An ash load of ~570 g $m^{-2}$ was applied to each plant using a homemade ashfall simulator. We estimated the leaf surface area covered by ash from pictures taken before and immediately after the simulated ashfall. The ImageJ software was used for image processing and analysis.

Our results show that leaf coverage by ash increases with decreasing particle size. Exposure of tomato and chilli pepper to ash ≤ 90 µm always led to ~90% coverage of the leaf surface area. For coarser particles sizes (i.e. between 125 and 500 µm) and dry condition at leaf surfaces, a significantly higher percentage (on average 29 and 16%) of the leaf surface area was covered by ash in the case of tomato compared to chilli pepper, highlighting the influence of leaf pubescence on ash retention. In addition, for particle sizes between 90 and 500 µm, wetting of the leaf

surfaces prior to ashfall enhanced the ash cover by 19 ± 5% and 34 ± 11% for tomato and chilli pepper, respectively.

These findings highlight that ash deposit thickness alone cannot describe the hazard intensity accurately. A thin deposit of fine ash (≤ 90 μm) will likely cover the entire leaf surface area, thereby eliciting a disproportionate effect on plant foliage compared to a thicker but coarser deposit. Similarly, for a same ash depth, leaf pubescence and humid conditions at the leaf surfaces will enhance ash retention, thereby increasing the likelihood of damage. Our study will contribute to improve the reliability of crop fragility functions used in volcanic risk assessment.