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Pesticide residues in intensive agricultural soils are higher than in agroforestry systems – a case study on the Indonesian Dieng plateau

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With more than 260 million inhabitants, Indonesia is the fourth-most populous country in the world. Java is home to 60% of Indonesia's population, therefore there is a high demand of agricultural products, produced mainly by intensive agricultural practices. This leads to excessive use of pesticides and fertilizers, especially for cash crop production, endangering soil functions and long term fertility. In addition, residues of persistent organic pollutants and pesticides (POPs) potentially threaten water sheds and human health. In the present study we aim to identify and quantify pesticide residues in soils from two different farming systems on the Dieng plateau, by comparing two villages. Both villages are in close vicinity to each other (15 km distance) situated on the same parent material, part of the same catchment area and have similar climate.
These two villages have very different smallholder farming systems. In Leksana, the farms integrate agroforestry with crop and livestock, while in Penanggungan, the farmers practice intensive cropping in a cleared landscape with a minimum presence of trees without livestock. From each farming system five fields were selected based on the following criteria:
For agroforestry, fields were selected in which at least five crops per season and three tree species were grown. In addition, the fields had to be protected by natural boundaries like trees, or buffer areas to avoid cross contamination of pesticide use from other farming systems. For intensive cropping fields, a maximum of three crops per season was grown. Contrary to agroforestry systems, there are hardly any buffering areas or trees.
Farmers were interviewed about pesticide use and land management practices; soil samples were taken in each field with a cylinder from the top 10 cm. To ensure representative values, four samples were taken per field, between crops, or crops and trees. Soil samples were sieved to 2 mm and air dried for transportation and storage. Pesticide residue analyses were conducted after extraction via an adapted QuEChERS method for tropical soils; extracts were screened for more than 500 pesticides using HPLC-MS/MS and GC-MS/MS. Additionally N-(Phosphonomethyl)glycin (known as glyphosate) and its metabolite aminomethylphosphonic acid (AMPA) were analyzed with HPLC-MS, after pre-column derivatization with Fluorenylmethyloxycarbonylchloride (FMOC). Basic physico-chemical soil parameters (Ctot, Corg, Ntot, pH, EC, DOC, bulk density, water infiltration, soil texture and colour) were correlated to pesticide residue load.
Glyphosate and metabolite residues were found, in each of the tested fields. EU-banned pesticides like DDT and other POPs were found in both systems. Intensive cropping fields, show between 13 and 25 different pesticide residues. In contrast, agroforestry fields present between four and eleven residues. Quantities of pesticide residues are generally higher under intensive cropping than under agroforestry. We complement chemical analyses with farmer interviews on pesticide use.
It can be concluded that agroforestry systems manage pest load with less pesticide requirement than intensive cropping systems, and also provide potential benefits against soil erosion and land sliding in areas like the Dieng plateau.