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From village to region: soil micronutrient dynamics across scales in northern Ghana

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Abstract

A clear understanding of the spatial distribution of soil micronutrients is vital for addressing agricultural productivity and nutritional outcomes in Northern Ghana, where soil fertility limitations influence food quality, and high-quality soil data is lacking. The effectiveness of soil micronutrient assessment is strongly shaped by the scale of mapping, which determines the balance between cost, level of detail, and practical utility. At broader (regional) scales, mapping offers a cost-efficient means of identifying general patterns and priority zones of micronutrient deficiency. Such approaches are valuable for national planning, policy formulation, and targeting interventions. However, coarse-scale assessments often mask local heterogeneity, limiting their usefulness for site-specific management. Conversely, fine-scale (village to field-level) mapping captures detailed spatial variability, enabling precise recommendations for soil amendments. This level of detail enhances decision-making at the farm scale but comes with significantly higher costs. This study explores the utility of mapping scales for soil micronutrients in Northern Ghana. At medium scale, plant-available micronutrients (Zn, Cu, Mn, and Fe) were not significantly different across different geological formations of Northern Ghana, implying that cheaper, cost-efficient regional soil micronutrient data may be adequate for crop productivity management and nutrition security. This is more so for iron (Fe) and manganese (Mn) which are available in adequate amounts for proper crop growth and productivity across the entire region, and molybdenum (Mo), which was too low to detect. For Fe, Mn and Mo, costly, detailed, site-specific assessments may not be required as one management recommendation may be applied across the entire region. The situation is different for copper (Cu) and zinc (Zn), whose spatially variable amounts range from low to moderate. For both, the regional averages were also distinct from medium scale (by geological formations) and village averages. As such, applying the same treatment across the region would result in deficiencies arising from inadequate application in some areas and toxicities arising from over application in others. Consequently, to enable precise management recommendations for increased crop productivity and nutrition security, site-specific (medium to village-level) mapping is required to capture the spatial variability of Cu and Zn across Northern Ghana.

Keywords: Mapping, micronutrients, scale, site-specific, spatial variability

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