Scanning Seeds for Sustainability: Portable X-ray Florescence as a Game Changer in Biofortified Crop Breeding

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Background & Rationale

Micronutrient malnutrition (Hidden Hunger) remains a major global challenge, especially in regions dependent on plant-based diets. Biofortification through crop breeding offers a sustainable resolution by enhancing the mineral content of staple crops such as cereals and legumes. However successful biofortification depends on the availability of rapid, accurate and scalable methods for assessing seed nutrient composition. Conventional analytical techniques such as AAS and ICP are precise but destructive, chemical-intensive, and time-consuming, limiting their use inn large breeding programs. **Portable X-ray Florescence (pXRF) is a non-destructive, reagent-free technique enabling rapid multi-element analysis** of seeds. Its **high-throughput capacity, minimal waste generation, and preservation of seed material** make pXRF, a **sustainable alternative** for accelerating nutrition focussed crop breeding.

pXRF Vs Conventional Method

Aspect	pXRF	Conventional
Sample Nature	Non-destructive	Destructive
Sample preparation	Nil or minimal	Acid digestion
Chemical Use	None	High
Waste generation	Negligible	Hazardous liquid
Analysis time	Seconds per sample	Hours per batch
Throughput	High	Low to moderate
Field deployability	Portable	Lab-bound
Seed recovery	Possible after analysis	Not possible

Objectives

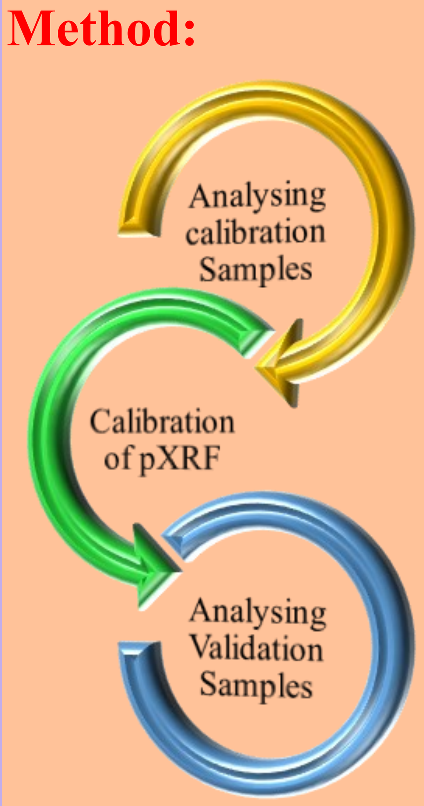
- To employ portable X-ray fluorescence (pXRF) for rapid seed mineral profiling.
- To establish a calibration–validation workflow for reliable elemental analysis.
- To evaluate pXRF as a sustainable alternative to conventional wet-chemistry methods.
- To demonstrate the utility of pXRF in nutrition-oriented crop breeding.

Limitations

- Limited sensitivity for light elements (e.g., N, P, S).
- Accuracy is influenced by particle size.
- Requires proper calibration with reference methods.
- Best suited for screening and not trace level quantification.
- High initial cost.
- Lower detection accuracy at very low concentrations
- Moisture content can affect signal intensity.
- Performance varies across different crop species and seed sizes.

Material: Mini-core set of cowpea from national core of ICAR-NBPGR.

Method:



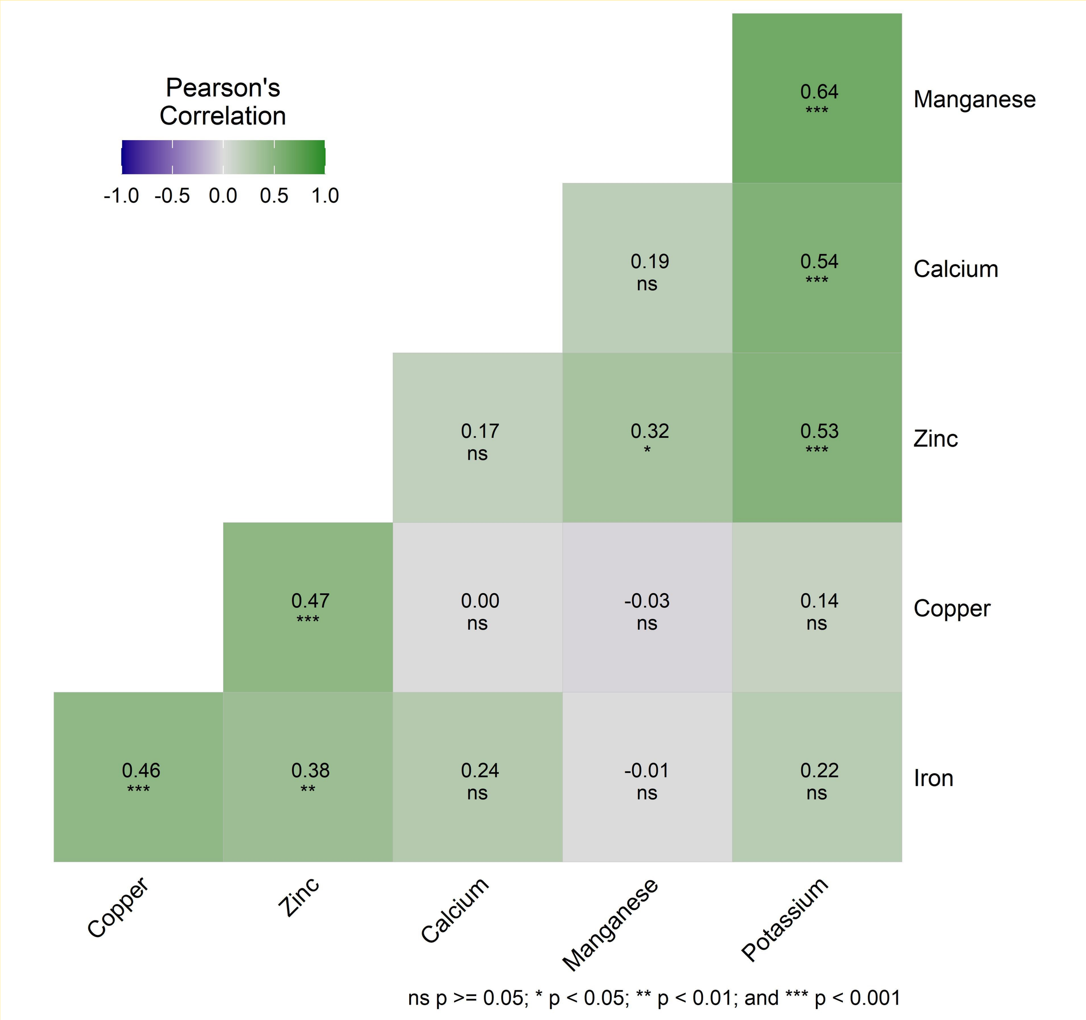
Scan Cycle: 20 second

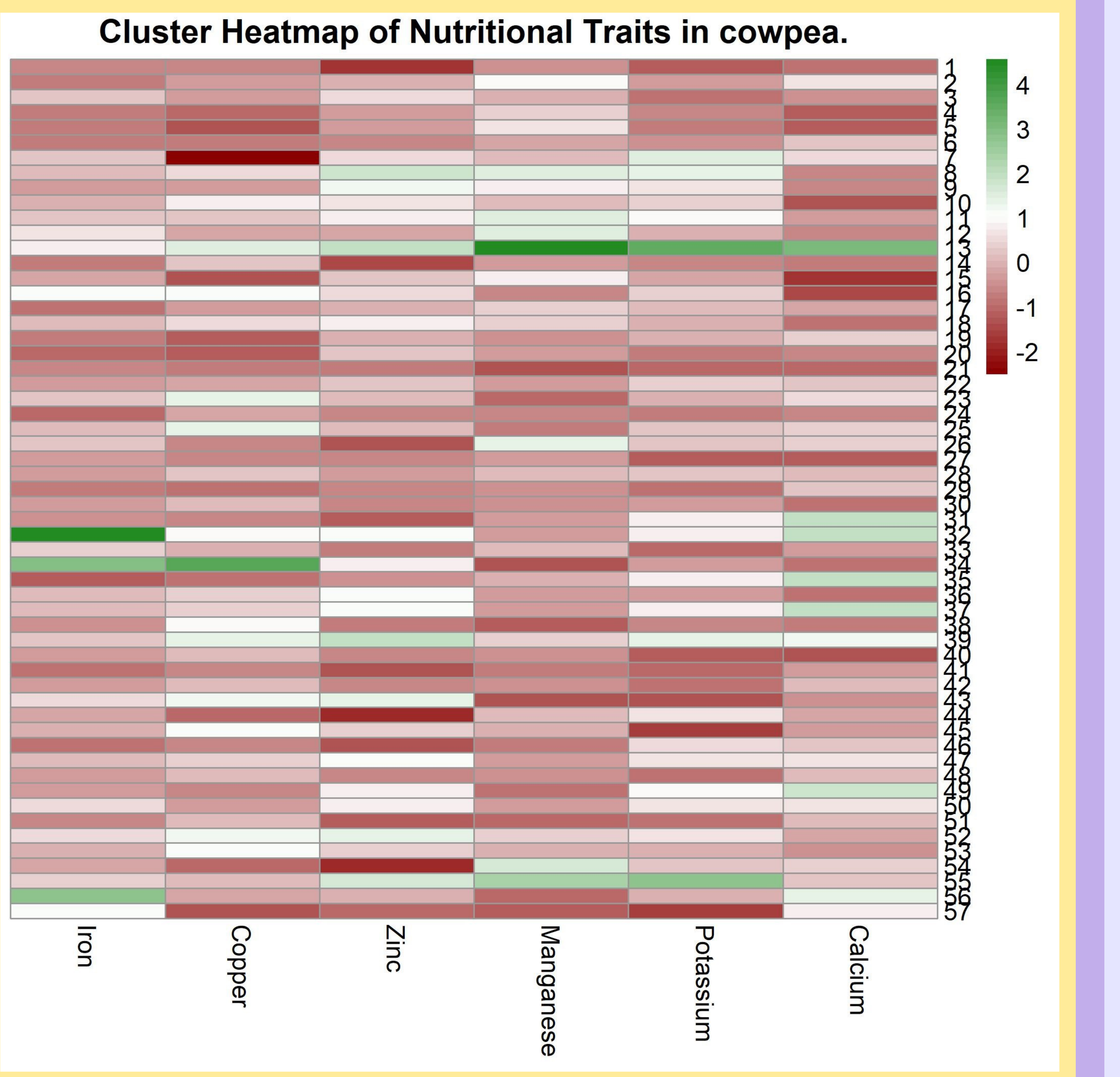
Elements Determined:

- Potassium
- Iron
- Zinc
- Manganese
- Calcium
- Potassium

Results

Significant genotypic variation observed for seed mineral concentrations.





Sustainability Impact

- Non-destructive analysis preserves valuable seed material.
- Reagent-free workflow excludes acid digestion and hazardous waste.
- Low energy requirement compared to conventional methods.
- High-through put capability reduces time, cost and resource use.
- Supports green analytical chemistry and responsible research practices.

Scan here for the pXRF

Scan here for the research paper

Implications for breeding

- Enables early-generation screening for seed mineral traits.
- Facilitates identification of nutrient-dense donor genotypes.
- Allows simultaneous selection of multiple micronutrients.
- Reduces breeding cycle duration and analytical bottlenecks.
- Integrates nutrition targets into precision breeding pipelines.

Conclusion

Portable X-ray Florescence (pXRF) provides a rapid, reliable, and environmentally responsible approach for seed mineral profiling. By combining non-destructive analysis with high-throughput capacity, pXRF enables efficient identification of nutrient-rich genotypes while minimising chemical inputs and resource use. Its integration into crop breeding programs can accelerate biofortification efforts, linking nutrition security with sustainable agricultural practices.

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