

Utilizing Plant Biomass Recycling for Sustainable Crop Protection: Advancing Climate Benefits and Food Security

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ABSTRACT

Recycling plant biomass plays a pivotal role in mitigating climate change. Bananas, being the world's most exported fresh fruit, generate substantial waste, which is typically utilized for animal feed or fuel.

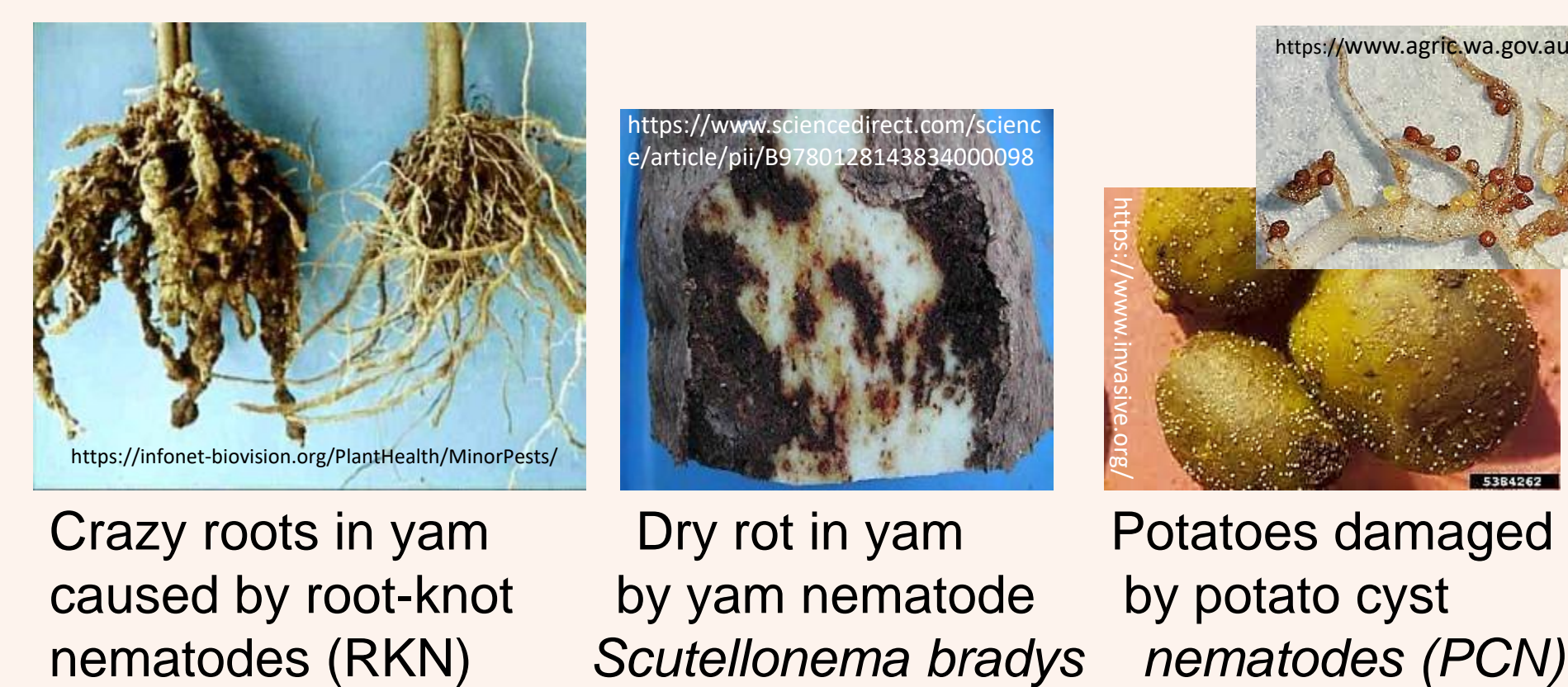
We introduce an innovative 'Wrap & Plant (W&P)' technology for seed treatment using biodegradable seed wraps from banana harvest wastes, employing a straightforward, chemical-free process. This approach aligns with the dual objectives of meeting the growing global food demand while recycling biomass into value-added products. These seed wraps possess customizable strength, controlled release properties, soil integrity, bioavailability, and biodegradability.

Over a span of seven years, we have successfully utilized these seed wraps to protect yam and potato crops from plant parasitic nematodes (PPN) in dozens of field trials in Benin and Kenya. Remarkably, our seed wraps, incorporating ultra-low doses of the active ingredient (AI) abamectin (Abm), consistently managed nematode populations and significantly increased crop yields during multiple field trials across various locations and years.

We firmly believe that recycling plant biomass to produce biodegradable matrices for sustainable crop protection represents a circular approach that not only enhances global food security amid a rapidly growing population but also contributes to carbon emissions reduction and the promotion of a more sustainable environment for future generations.

MOTIVATION

- Agriculture contributes an estimated 30% of global greenhouse emissions (GHE) because of off-target losses and multiple applications of pesticides.
- Biomass energy has the 4th highest carbon footprint.
- Over 80% of banana plant goes into wastes contributing to GHE.
- Global concerns about accumulation and environmental effects of microplastics generated by synthetic polymers as delivery platforms for AIs in agricultural formulations.
- PPN cause annual loss of \$175 billion to crops.
- Yam in Benin and potatoes in Kenya are highly impacted crops dictating the economy and food security of this highly food insecure region, i.e., 43% of food-insecure people live in sub-Saharan Africa (SSA).



- Limited bioavailability of Abm due to binding with soil, leads to multiple applications.

Objectives

- To minimize over-use and multiple applications of pesticides.
- To recycle plant biomass as an alternative controlled delivery platform for agricultural AIs.
- To develop a sustainable and affordable technology for enhanced food security for small stakeholder farmers in SSA & eventually beyond.

APPROACH & OUTCOMES

Approach (Wrap & Plant)

To explore hollow and coarse fibrous structure and amazing combination of lignin and cellulose in banana fiber to sustainably generate paper-like matrices (BP) as controlled and targeted delivery platform.

Development & Efficacy Evaluation

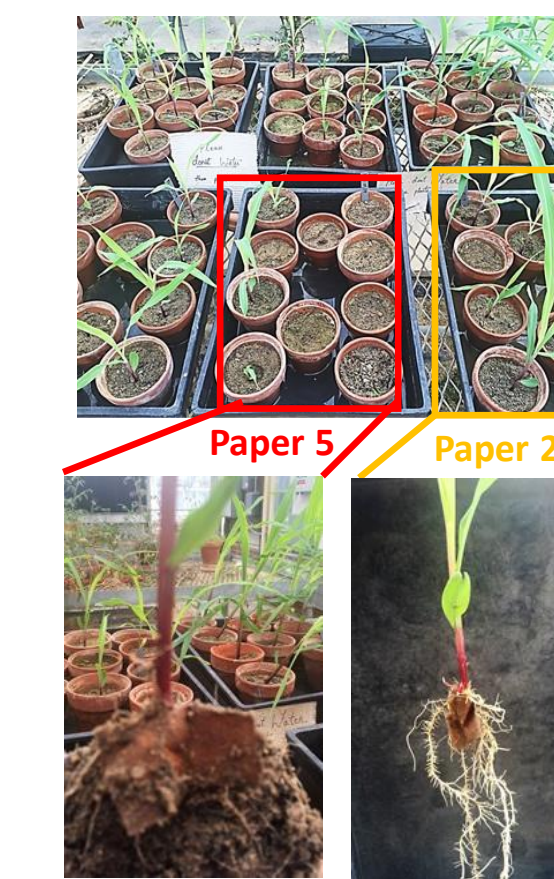


Fibrous slurry is mechanically beaten (refined) for a specific time to generate handsheets of different strengths and morphology

Strength vs Germination

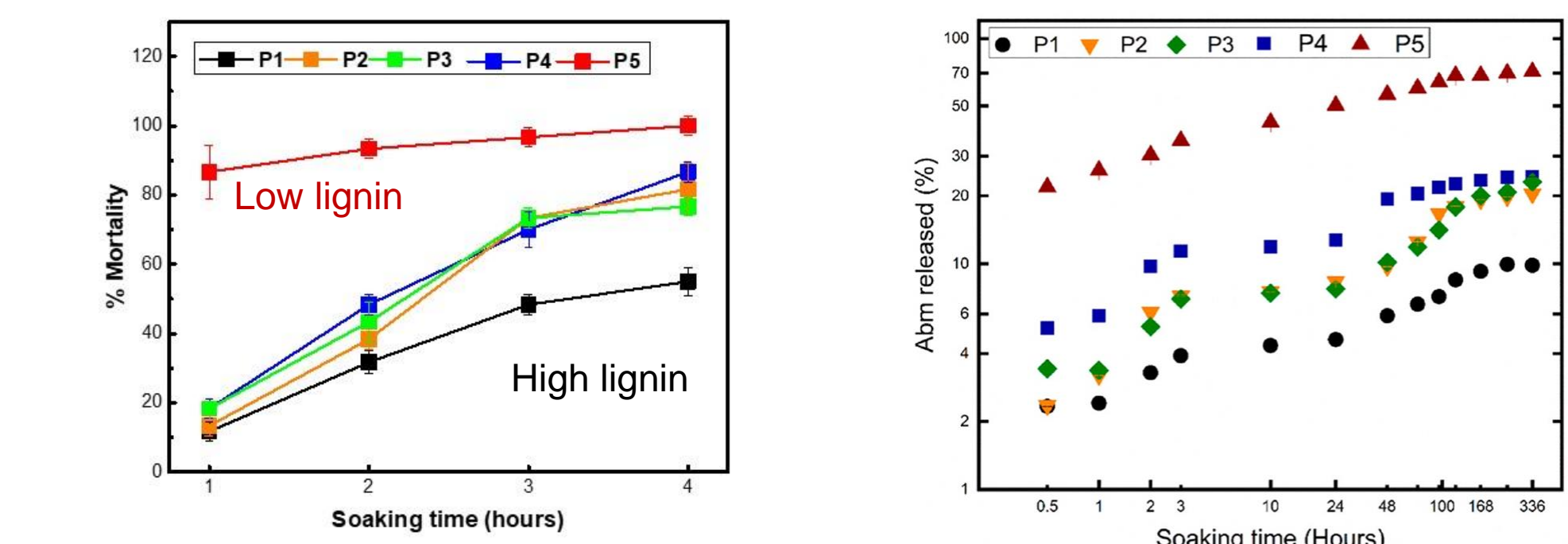
- The seed wrap should not tear too easily
- Shouldn't be too tough to rupture

Samples	Refining time (Minutes)	Burst index (kPa.m ² /g)	% penetration through paper
Paper 1	0	0.46	100
Paper 2	2	0.85	100
Paper 3	5	1.32	100
Paper 4	10	1.66	80
Paper 5	30	3.29	0
Control	No paper wrap		100



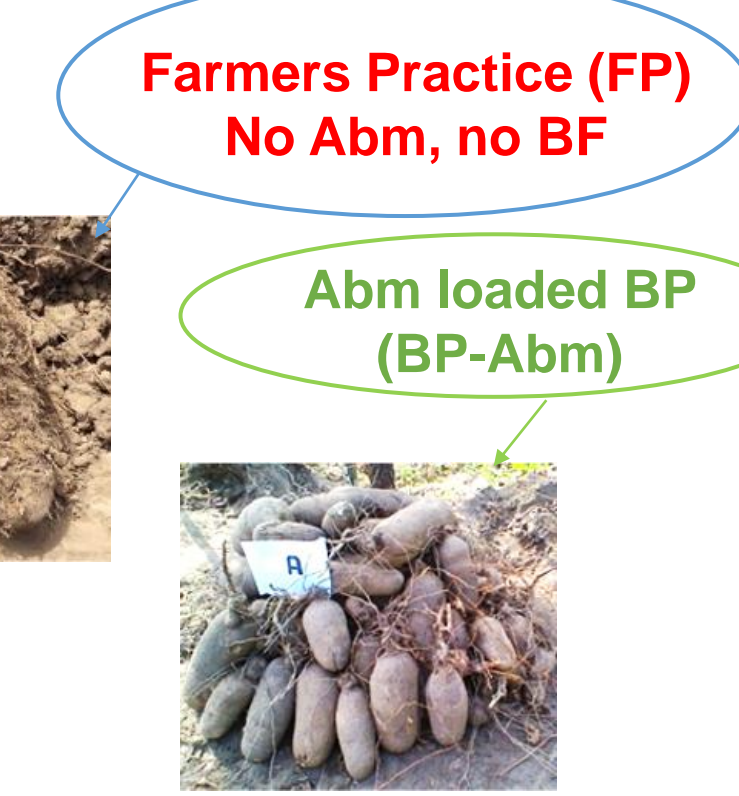
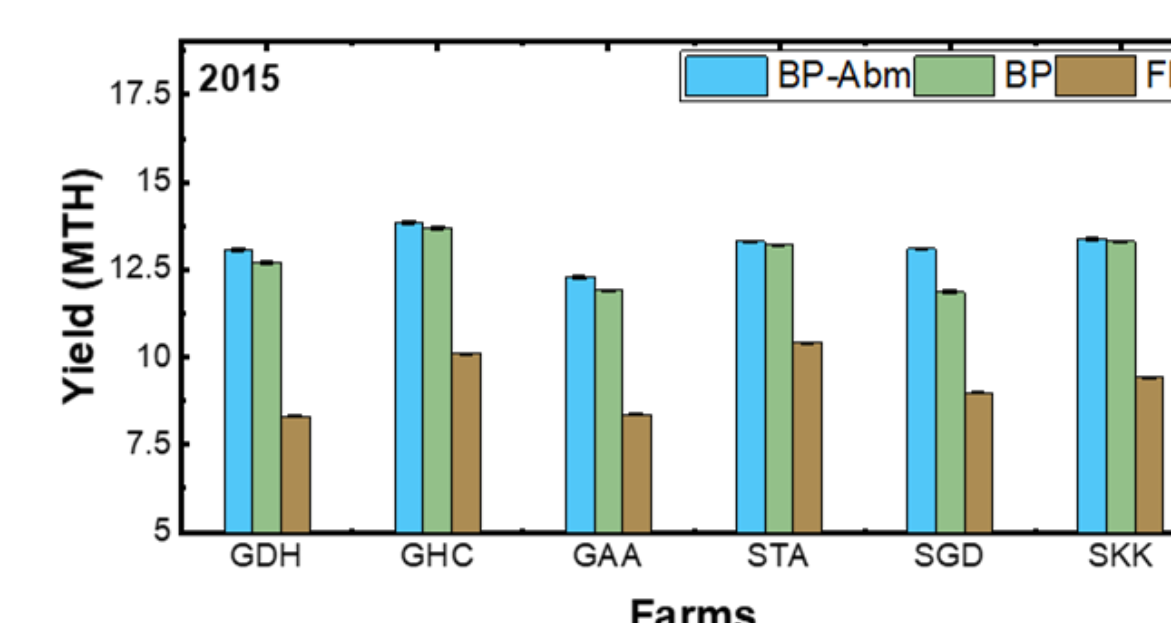
Composition & Release Profile

- Slow and sustained release of Abm from BP matrices

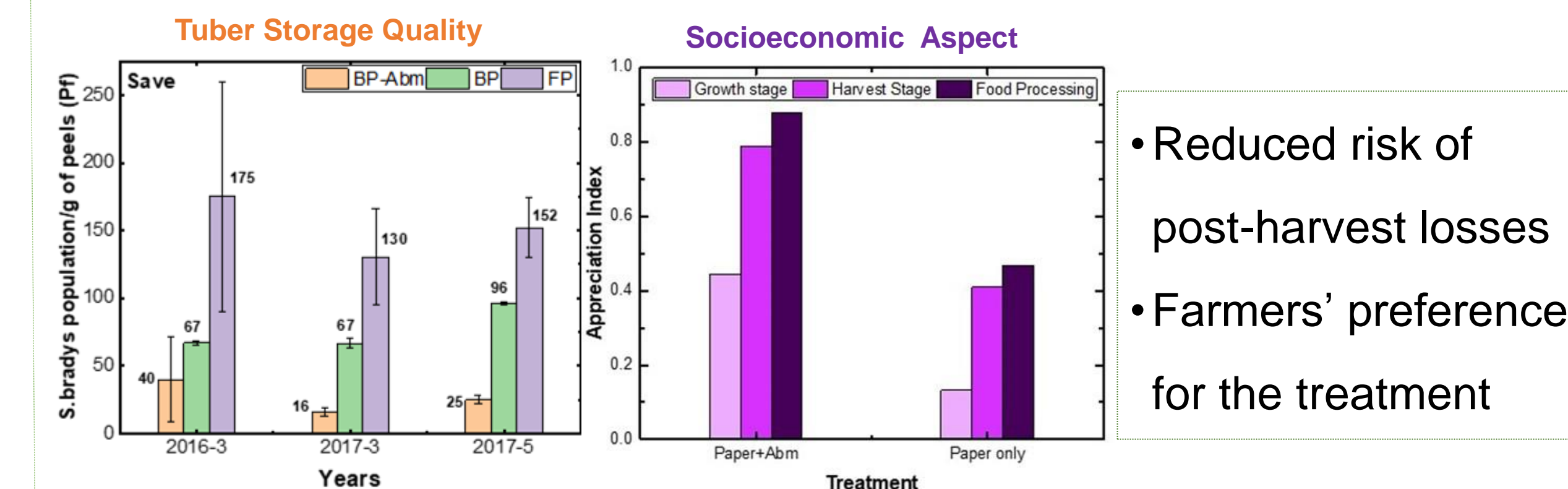


Field Trials

Yam in Benin

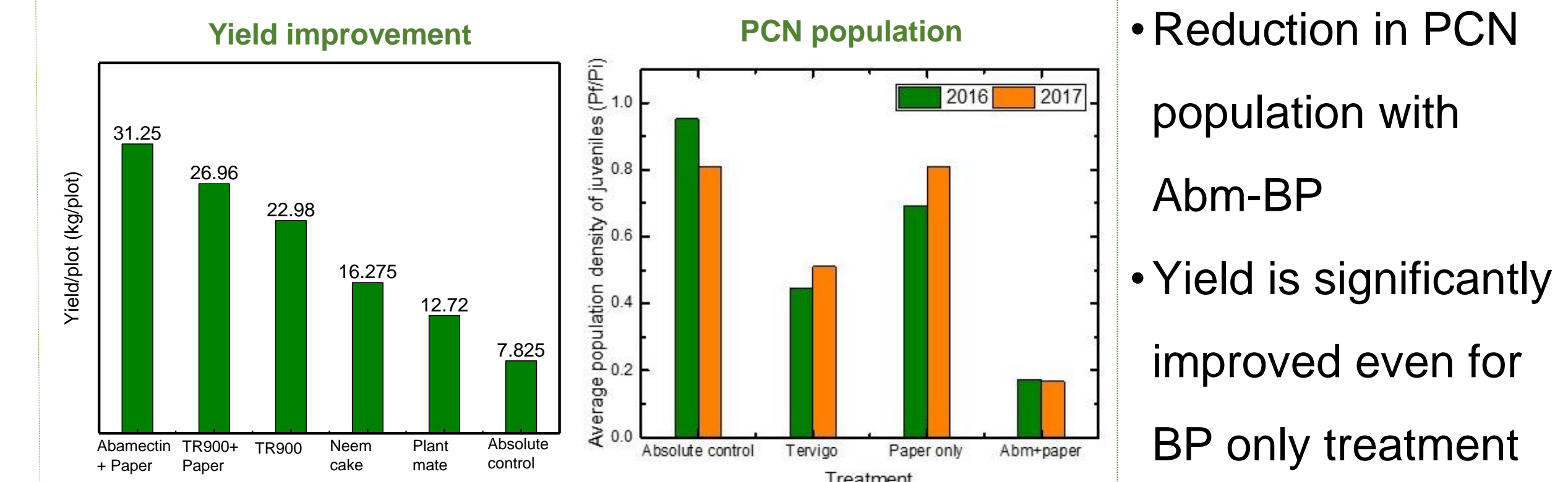


Post-harvest



- Reduced risk of post-harvest losses
- Farmers' preference for the treatment

Potatoes in Kenya



- Reduction in PCN population with Abm-BP
- Yield is significantly improved even for BP only treatment

Conclusions & Way Forward

- Seed wraps developed via a solvent-free approach can control PPN infestation to the seeds without or with a minimal load of AI (1/100th of commercial load).
- Use of biodegradable delivery platforms will minimize carbon footprints of petroleum-derived synthetic polymers.
- Compatible platform for agbiologicals.
- **Soteria Formulations** (www.soteriaformulations.com) has been recently incorporated as NC State spinoff to expand the technology for mechanized farming.

ACKNOWLEDGEMENTS



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KEY PUBLICATIONS

- Pirzada et al. Nat Food 4, 148–159 (2023).
- Opperman & coworkers. Nat Sustain 5, 425–433 (2022)
- Pirzada et al. Cur Opin Coll Int Sci 48, 121-136 (2020)