Revitalising Puerto Rico Towards Sustainable Vegetable Production

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Scientia

REVITALISING PUERTO RICO TOWARDS SUSTAINABLE VEGETABLE PRODUCTION

Currently, farming practices in Puerto Rico are largely unsustainable and little information exists to direct growers towards better practice. To address this issue, Dr Ermita Hernandez and her team at the University of Puerto Rico investigate sustainable management practices, including using enhanced crop varieties and improving soil health through the use of organic amendments.

In a world where the population is booming, the climate is changing, and wilderness areas are diminishing, the pressure for high-yield agricultural production is on the rise. Intensification is occurring on a global scale, with the island of Puerto Rico being no exception.

To exacerbate these stresses, climate change has undermined the situation, disrupting rain and drought cycles, amongst other things. The resulting warmer temperatures, coupled with poor management practices, are thought to be responsible for an increased spread of pests and disease, as well as the emergence of new ones.

To make matters worse, there has been very little attention given to improving the crop varieties grown in Puerto Rico. Puerto Rican produce lacks resilience to rising temperatures, drought and disease, meaning that a single bad year could have a serious impact on the local agricultural economy.

Scant availability of information regarding best management practices has resulted in the increased dependence on agrochemicals (pesticides and fertilisers) to obtain high yields. Poor management can lead to the soil becoming depleted of essential nutrients for crop growth, leading to a further increased need for fertiliser application. Agrochemical production costs both financially and environmentally – an unsustainable option for the future of farming systems.

Puerto Rico's Tomato and Sweet Pepper Produce

Sweet peppers and tomatoes, both members of the *Solanaceae* family, are particularly important local produce in Puerto Rico. Together, their cropping range covers 47% of land dedicated to vegetable farming in Puerto Rico. The degree of sweet pepper farming is, however, experiencing rapid declines as yields have become unreliable and farmers simply can't take the risk.

Tomato production hasn't yet faired so badly, although these are grown in vast monocrop swathes. This lack of genetic diversity increases the susceptibility of plants to new stresses, including pests and disease, with potential for island-wide devastation if these threats were to emerge. Tomato production

therefore remains on a knife edge, and the situation is worsened by economical out-competition from overseas produce. The result involves mass tomato export, whilst 85% of vegetables consumed in Puerto Rico are imported from overseas, raising issues of food security.

Puerto Rico's position of strength as a large-scale *Solanaceae* producer is becoming jeopardised. Current farming practices are simply not sustainable – if future generations are to survive, a solution must be reached. Fortunately, Dr Ermita Hernandez from the University of Puerto Rico has stepped in to make a change. With the help of her extension and research colleagues, Dr Hernandez strives to discern the most sustainable, low-input management protocols for Puerto Rican tomato and sweet pepper production.

Her ambitions stretch beyond research however; by means of field days and demonstrations, Dr Hernandez provides guidance and information to local agronomists and farmers so that sustainable solutions can be put into practice.

Already having obtained funding for multiple projects, Dr Hernandez states that her work will explore the 'best sustainable management practices that can reduce high farming inputs and cost, while maintaining long-term soil and crop health for important vegetable production.'

Crop Compatibility and Species Improvement

One of Dr Hernandez's projects has involved the incorporation of cover crops into agricultural practices. Cover crops are planted on cultivated land to improve soil conditions. In this case, the researchers planted leguminous species due to their ability to reduce weed growth and increase the amount of organic matter in the soil.

Cover crops also lead to improved soil stability due to the presence of their roots. This reduces soil erosion in storms and heavy rainfall events, during which vital nutrients would otherwise be lost, rendering soils less fertile.

Dr Hernandez and her colleagues wanted to explore more than just cover crop compatibility. The team also evaluated the yields of different species of tomato and sweet pepper and assessed the outcome of applying rhizobacteria to the soils. Rhizobacteria comprise a diverse group of microbes that live in the roots of plants, or the 'rhizosphere'. They offer beneficial services to their host plant, including nutrient provision, disease resistance and can even control plant hormones to stimulate growth or defence mechanisms. These favours are provided in return for hospitable living conditions in the roots, critical for rhizobacterial survival.

Plots in Practice

The research team planted cover crops in several plots two months before tomatoes and sweet peppers were introduced, both on conventional and organic agricultural land, for comparison against plots where no

legumes were incorporated. The cover crops were applied in the form of a 'green manure', that could be easily used by farmers.

The team then created plots within these initial plots. Three different species of tomato (Skyway 687, BHN 602 and Dixie Red) and three types of sweet pepper (SPP9301, Key West and Grenada) were grown under three different conditions. These different conditions involved the addition of rhizobacteria species – *Bacillus subtilis, Bacillus amyloliquefacien*s and no rhizobacteria as a control.

Once the crops had been planted, treatments applied, and the growing season was in full swing, Dr Hernandez's team faced the challenge of monitoring pests, disease and yield on each of the plots. This laborious process involved measuring the quantity, weight and dimensions of the fruits present, as well as soil characteristics such as nutrient levels and organic matter content to indicate quality improvement.

The trial was run over a two-year period, providing the team with insight into potential strategies for better management of small-scale Puerto Rican farms. The incorporation of leguminous cover crops caused an 18% increase in the weight of sweet peppers grown in the first year, whilst the SPP9301 pepper variety significantly outcompeted Key West and Grenada in terms of yield during year two. Dr Hernandez and her colleagues hypothesised that applying *Bacillus amyloliquefaciens* may reduce the chance of bacterial leaf blight, improving agricultural resilience.

Conversion to Compost

An additional project, also headed by Dr Hernandez, looked specifically at the concern of Puerto Rican farmers' reliance on agrochemicals, including pesticides and fertilisers, in order to obtain high yields. Production and application of these chemicals comes at a huge expense not just financially, but also environmentally. Organic compost, as a nutrient source, is also thought to improve the structure of soils, increase the amount of water they can hold, and introduce beneficial organisms, compared with inorganic alternatives.

Whilst applying too little compost could reduce yields, too much can pose serious environmental risks. Important nutrients, including nitrogen and phosphorous, can easily be lost from soils during rain or erosion, ending up in local waterways. This sudden spike of nutrients can have severe impacts on aquatic ecology, often resulting in toxic algal blooms. With no information available on local crop requirements for organic compost as fertiliser, the team's first task was clear. They aimed to tackle this shortfall in geographically distinct regions throughout Puerto Rico.

Dr Hernandez and her colleagues coordinated several field experiments to figure out the organic compost requirements for the specific soil types and climates observed across Puerto Rico. They applied compost to soils and then prepared the fields based on commercial agronomic recommendations. To test the effectiveness of compost fertilisation, the team weighed fruits from the crops grown in these fields and compared the results with expected yields from non-organic fertiliser usage. They also conducted chemical soil analysis before planting and after harvest, to determine the amount of nutrients taken up by the crop species.

Outreach and Education

Dr Hernandez and her team have gone to great efforts to ensure effective communication of their strategies to the farming community. Webinars, as well as demonstration trials are put on for growers, designed to guide them through the processes of compost application, mulch and irrigation installation, seedling transplantation, monitoring and sampling. The benefits of using cover crops have also been communicated in the same way, both to organic and conventional growers, and the research team provides hands-on experience to help put their theory into context.

The team has also developed an online portal to facilitate discussion between growers, extension educators and other stakeholders. This is linked to social networking platforms, which are routinely maintained by Dr Hernandez, to ensure that relevant information is passed on and growers are kept up-to-date.

Future Directions

Dr Hernandez's work is ongoing, but this hasn't stopped her from keeping one eye on the future. She anticipates the creation of an Extension and Research Vegetable Program, to provide solutions and management strategies to growers throughout the vegetable industry. This will be complemented by a grower's handbook that describes 'the amount of compost needed for each vegetable crop and the best integrated crop management tactics in various geographical regions and growing periods in Puerto Rico.'

Meet the researcher

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Dr Ermita Hernandez completed an associate degree in Horticulture at the University of Puerto Rico in 1999. Her early passion in the field, combined with her clear ability to inspire others, led her to pursue a degree in Agricultural Education thereafter she worked as an Agriculture Teacher at an elementary school at Puerto Rico. She went on to diversify her skills and knowledge with a Master's degree Plant Pathology at The Pennsylvania State University, swiftly followed by a Graduate Research and Teacher Assistant position at the same institution. Pennsylvania State University was clearly impressed with her tenacity in the field, offering Dr Hernandez a PhD position in Horticulture which she completed in 2013. She then returned to the University of Puerto Rico, where she was offered her current position of Assistant Professor/Vegetable Extension Specialist. Dr Hernandez's determination and commitment to the field is admirable, providing valuable contributions to current agroenvironmental research.

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SPECIAL THANKS

Dr Consuelo Esteves and Professor Irma Cabrera from the Plant Diagnostic Clinic at the Agricultural Experiment Station at Juana Diaz PR.

FUNDING

USDA-NIFA
USDA-NRCS
Puerto Rico Agricultural Extension Service Agency