# Agrivoltaics East Africa: Spinach Performs Better than Sweet Pepper under Agrivoltaics in Tanzania, Guiding Future Climate Change Resilient Food Systems Intertwined with Low Carbon Electricity Supply

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## 1. Introduction: Food, energy, water and climate change in Tanzania

The potential for agrivoltaics (AV) in Tanzania is substantial, due to a high need for energy security (60% of people lacked electricity access in 2020) [1], abundant solar radiation (4-7 kWh/m$^2$) [2], and food production vulnerability to ongoing climate change (major crop yields are predicted to decrease by 8-45% by 2050) [3]. To explore this potential, we are studying the morphology and yields of spinach and sweet pepper, the irrigation consumption, and electricity generation from an off-grid AV system in Morogoro.

## 2. Methods: A 36 kWp off-grid agrivoltaics system in Morogoro

The 36 kWp AV system (Fig 1a) is located at Sustainable Agriculture Tanzania, Morogoro, Tanzania. The system dimensions are 34(w) x 13(d) x 3(h) m, and it has a panel density of 50%, which is appropriate for the location due to the high solar radiation and the need to reduce evaporative water loss. A neighbouring open-field 34 x 9 m control plot (C) growing the same crops is used for comparison. Between Jul-Oct 2022 we recorded the yields of spinach (AVn=756, Cn=526) and sweet pepper (AVn=699, Cn=562). Control yields were standardised to AV crop numbers to compare crop responses. Leaf length, width and weight was recorded during the first two spinach harvests, with AV data separated into “under panel” and “under gap”.

## 3. Results & conclusion: Morphological responses and varying crop yields

Standardised spinach yields were 82.1% greater underneath the AV system compared to the control (Fig 1b). One plant response to shade is to grow larger leaves to capture more light, and this is supported by our morphology results, which show significantly longer, wider and heavier leaves from the AV plot compared to C (Fig. 2). Sweet pepper yields, however, were 31.5% lower (Fig. 1b). Specific harvest data shows that the control plants fruited earlier (3a) and produced more fruits per plant (3b), which offset the slightly heavier individual fruits (3c) and lack of significant difference in yield per fruiting plant (3d) to ultimately produce greater yields (3e-f). Our results inform crop selection for agrivoltaics in East Africa, suggesting that leafy greens may have a more positive productivity response than capsicums. At the conference we will present irrigation and financial data along with these results, and we will have data on onions and beetroots.

## 4. A call for a dynamic agrivoltaics research database

Agrivoltaics research has grown rapidly over the past decade, spanning six continents and various social and environmental contexts. While a range and wealth of valuable data is being published, comprehensive and expansive overviews are limited to review papers, which in turn are static and only reflect data published prior to the review. We therefore call for a dynamic, international database where research groups can share published (and preliminary, if they wish) results, thus providing a continuous and evolving source of information to inform future R&D activities. A consortium could seek funding to create and manage this.

## 5. Figures

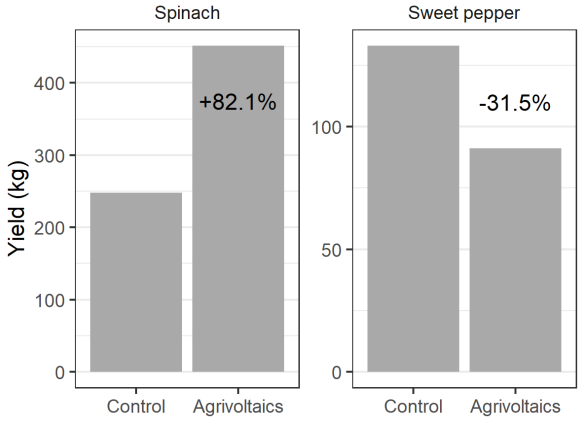
1a)  1b) 


Fig. 1a: 36 kWp off-grid agrivoltaic system; 1b: Standardised spinach and sweet pepper yield results.

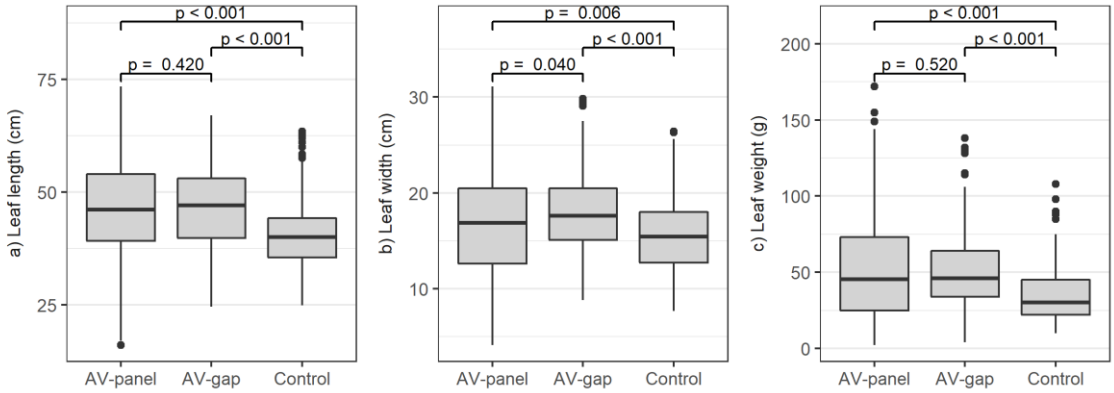



Fig. 2: Spinach leaf length (a), width (b) and weight (c). p-values calculated with Wilcoxon test.

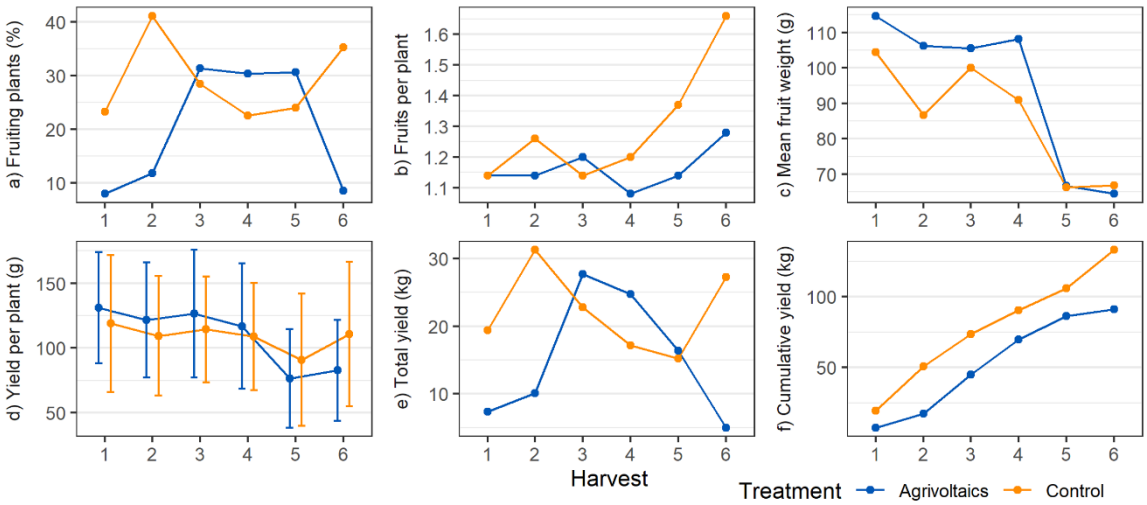



Fig. 3: Sweet pepper yield results per harvest. Total yields (3e, 3f) standardised for comparison.

## References

[1]The World Bank. *Access to electricity; SE4ALL database*. https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=TZ (2020). *Accessed 21st October 2022.*

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[3]Adhikari, U., Nejadhashemi, A. P. & Woznicki, S. A. Climate change and eastern Africa: a review of impact on major crops. *Food Energy Secur.* **4**, 110–132 (2015).