Soil Section

Funded projects

Tittle; Tonga Desalination Plant Project and Crop Trials (The effects of saline irrigation on Pacific crops)

Funded by the Australian National University through (DEFAT) Department of Foreign Affairs and Trade.

Project objective; To measure the impact of watering with slightly saline water, that is 5% and 10% of salinity in seawater (Impact of salt on growth and yield of Taro and Yam)

Introduction

Salinity poses a significant and growing threat to global agriculture, with anthropogenic issues such as groundwater salinisation and sea level rise exacerbating the problem. Salinity currently affects over 10% of the world's land (approximately 1.4 billion hectares) and another billion hectares are at risk (FAO, 2024). Salt impacts crops through the osmotic and ionic effects (Munns and Tester, 2008). In the osmotic effect, salt in the root zone makes it harder for plants to absorb water through osmosis, reducing turgor pressure and the rate of photosynthesis. In the ionic effect, the accumulation of sodium and/or chloride ions in tissues causes senescence. These effects typically result in salt-stressed plants having slower growth rates, lower rates of photosynthesis, and altered concentrations of macro- and micro-nutrients (Fu et al., 2025; Lloyd et al., 2021; Munns and Tester, 2008).

Materials and methods

Field site and treatments

The experiments took place in a field site at the Vaini Experimental Farm, Vaini, Tonga (-21.203, -175.199; Fig. S1 in Supporting Information). Soil composition was measured through fractionation at depths of 0–15 cm and 15–30 cm (n = 3). At 0–15 cm, composition was 8 ± 2% clay, 25 ± 3% silt, and 67 ± 4% sand. At 15–30 cm, composition was 13 ± 8% clay, 16 ± 2% silt, and 71 ± 7% sand. At both depths the soil was classified as sandy loam (USDA, 2017). Field capacity was measured using a 200 mm soil moisture probe (HydroSense II, Campbell Scientific) 24 h after the soil had been saturated. Field capacity was 49.4 ± 1.9% (n = 3). Weather conditions were measured by the nearby Fua'amotu weather station (Ministry of MEIDECC, 2025). Over the nine-month growth period for Experiment 1 (June 2024 to February 2025), rainfall totalled 1479 mm and mean daily minimum and maximum temperatures were 20.7 ± 0.2ºC and 27.5 ± 0.1ºC respectively. Over the seven-month growth period for Experiment 2 (September 2024 to April 2025), rainfall totalled 1799 mm and mean daily minimum and maximum temperatures were 22.5 ± 0.1ºC and 29.1 ± 0.1ºC respectively. Monthly rainfall totals and mean daily minimum and maximum temperatures over the entire experimental period.

Four irrigation treatments were implemented: rainfall only (no irrigation), groundwater irrigation, low salt irrigation (3–4 dS m^{-1}) and high salt irrigation (6–7 dS m^{-1}). Groundwater in Vaini contains low levels of salt, ranging between 0.4 and 0.9 dS m^{-1} during the experiment. The low and high salt irrigation treatments were produced in 500 L tanks by adding salt (AG Coarse Salt, Summit) to groundwater until the target conductivity levels were reached. Conductivity was measured using an electrical conductivity tester (EC60, Milwaukee Instruments). The low and high salt treatments were chosen to approximately represent 5% and 10% of the salinity of seawater. These levels are within the target range for TDD output water and were unlikely to permanently damage the soil at the field site (Xu et al., 2024; Xu and Torres, 2025).

Results

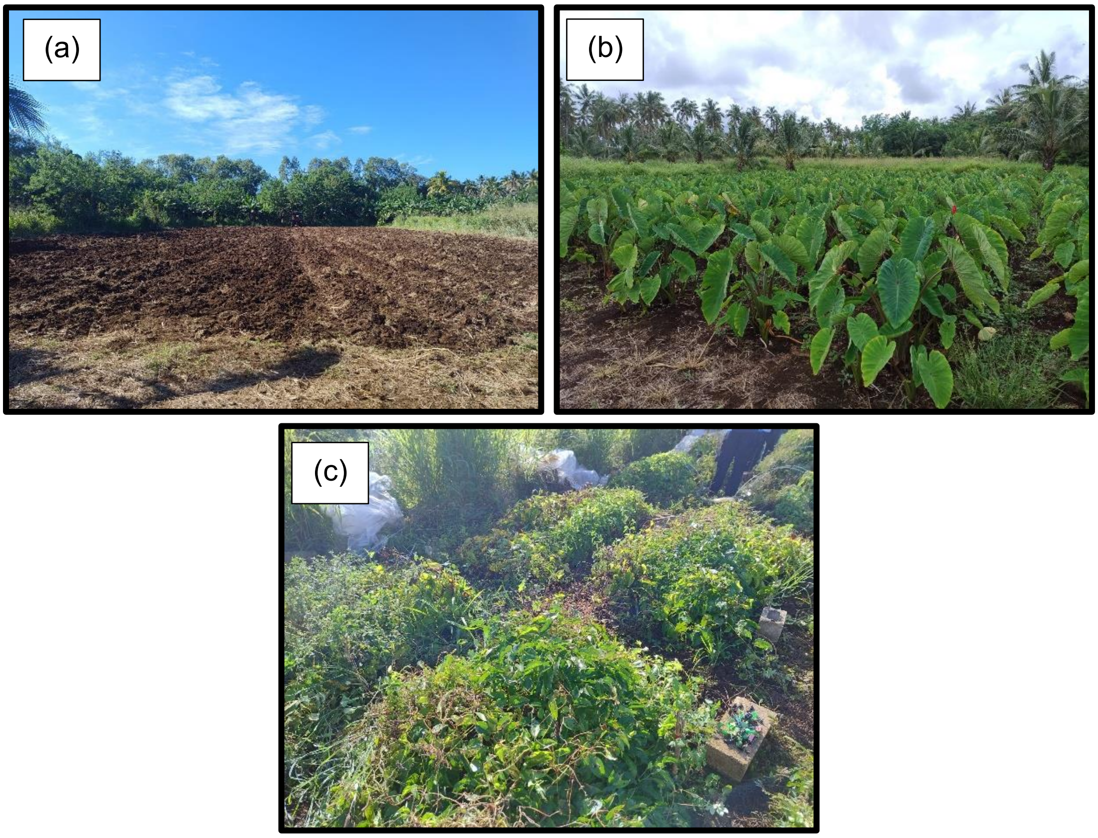


Figure S1. Photos of the experimental field site in Vaini, Tonga. Picture (a) shows the field before planting. Picture (b) shows the fully grown experimental taro plants. Picture (c) shows the fully grown experimental yam plants.

Experiment 1: Taro corm dry weight was lower with high salt irrigation, other parameters were unaffected

In Experiment 1, taro plants were watered as follows: rainfall only (no irrigation), groundwater (<1 dS m^{-1}), low salt (3–4 dS m^{-1}) or high salt (6–7 dS m^{-1}). Mean corm dry weight was significantly higher in plants irrigated with groundwater (528 g) than those irrigated with the high salt treatment (398 g). No other significant pairwise differences in corm dry weight were observed. Plants irrigated with groundwater also had higher corm (1635 g) and aboveground (632 g) fresh weights than high salt-treated plants (corm = 1439 g, aboveground = 500 g), but these differences were not significant (Fig. 2a-c; Table S2 in Supporting Information). High salt-treated plants had a significantly lower mean corm dry matter content than groundwater-treated plants, but there were no significant differences in leaf dry matter content among treatment groups.

No significant effect of treatment on number of leaves, leaf length or leaf width was detected (Fig. 3). The effect of treatment on chlorophyll concentration was different depending on sampling time. At week 16, plants irrigated with the low salt treatment (696 µmol m^{-2}) had a significantly higher chlorophyll concentration than high salt-treated plants (645 µmol m^{-2}), but there was no significant effect of treatment on chlorophyll concentration at week 27 (Fig. 4a,b; Table S2). There was no significant effect of treatment on stomatal conductance at week 16 or 27 (Fig. 4c,d; Table S2). There were no significant differences in $EC_{1:5}$ among the Experiment 1 soil samples at either 0–15 cm or 15–30 cm, which were taken pre-treatment and after the groundwater and high salt treatments (Table 1). It is worth noting that there was a lot of rainfall during the taro experiment

Overall, leaves had higher concentrations of each of the measured nutrients than the corms, except for sodium and silicon (Table 2). In terms of treatments, no significant differences in macro- and micro-nutrients were detected between leaves from the groundwater and high salt treatment groups. In contrast, corms exhibited several important treatment effects: corms of high salt-treated plants had significantly higher concentrations of calcium (which can be used as a proxy for calcium oxalate) and sodium than groundwater-treated plants, while phosphorus concentration was significantly lower.

Experiment 2: Differences between two yam cultivars irrigated with saline water

In Experiment 2, two yam cultivars were irrigated with groundwater (<1 dS m^{-1}) or the high salt treatment (6–7 dS m^{-1}). Significant effects of cultivar on tuber dry weight, tuber fresh weight and aboveground fresh weight were detected, but significant effects of treatment were not. Mean tuber fresh weight was higher in *D. alata* cv. kahokaho (6792 g) than *D. cayenensis* ssp. *rotundata* cv. lose (3999 g). Mean aboveground fresh weight was higher in cv. lose (2872 g) than cv. kahokaho (919 g) (Fig. 5). There were several other differences of note between the two cultivars. In cv. kahokaho, mean tuber fresh and dry weights were slightly higher in groundwater-treated plants than high salt-treated plants whereas, in cv. lose, the opposite was true, though these differences were not significant. Tuber dry matter content was significantly higher in cv. lose than cv. kahokaho but was not affected by treatment. Leaf dry matter content was not significantly affected by treatment or cultivar.

Chlorophyll concentration was also significantly different between the two cultivars, but not between the two treatments. Cv. kahokaho had a significantly higher concentration than cv. lose. No significant difference was detected in stomatal conductance, irrespective of treatment or cultivar. In Experiment 2, soil salinity was significantly higher under the high salt treatment than under the groundwater treatment. Soil salinity was not significantly affected by cultivar.

There were some significant differences in macro- and micro-nutrient concentrations between cultivars and treatment groups. There are three noteworthy points: Firstly, within cultivars, leaf nitrogen concentration (and protein, which is derived form that value) was slightly higher in plants irrigated with groundwater, but these differences were not significant. Secondly, mean sodium concentrations were higher in leaves than tubers within every treatment × cultivar group, except for high salt cv. kahokaho plants. No significant effects of treatment on sodium concentration were detected within leaves or tubers. Thirdly, calcium concentration was much higher in leaves than tubers but, within organs, there were no significant differences between plants irrigated with groundwater or the high salt treatment.

Conclusion

Regarding our hypotheses, we detected significant reductions in dry weight with increased salinity in taro but not yam. Sodium was successfully prevented from entering young leaves in taro, protecting the vital photosynthesising tissues. In yams, it appeared that sodium was not excluded from young leaves, but leaf sodium did not accumulate to a level that reduced chlorophyll concentrations. Yam appears to be the more salt tolerant of the two crops, with no significant yield losses under the high salt treatment. This result occurred in spite of the fact that yams were grown under rainfall shelters while the taro were not, meaning root zone salinity was likely consistently higher for yam than taro. Our results also suggested that *D. cayenensis* ssp. *rotundata* cv. lose might be more salt tolerant than *D. alata* cv. kahokaho, but the differences in tuber fresh and dry weight among treatment groups were not significant.

Both taro and yam were able to tolerate irrigation water salinity of 6–7 dS m^{-1} for several months in a field environment, supporting the results of previous greenhouse studies (reviewed by Myrans et al., 2024). Therefore, both crops appear to be suitable as model test species for piloting an irrigation system that uses emerging desalination technologies (when they become available), and it is expected that yields of both crops would be increased by saline irrigation during the short periods of drought frequently experienced by Tonga and other Pacific Island countries. Repeating our experiments in an El Niño year would be valuable for verifying this hypothesis. It would also be interesting to repeat the taro experiment with more cultivars and using the polytunnel rain shelters. Continued research into the salt tolerance of a wide variety of crops and cultivars, especially those from the Pacific Islands, is needed to boost agricultural resilience in the Pacific and better understand crops suited to slightly saline irrigation water.

Funded Projects

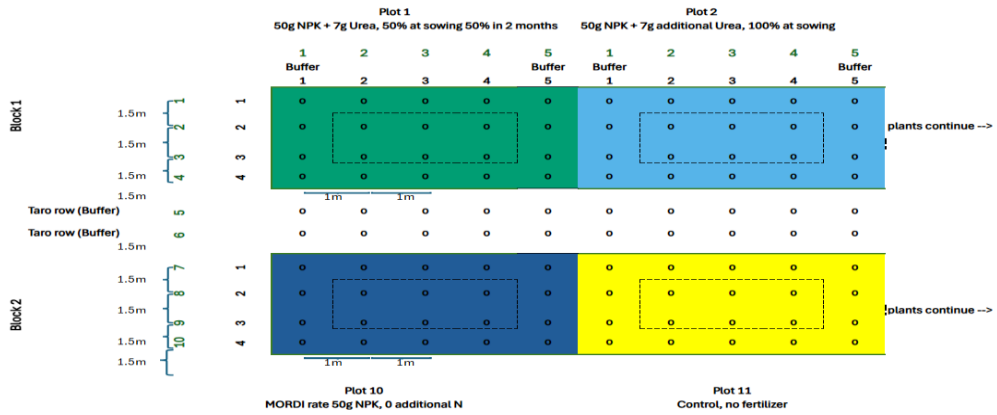
Tittle; Soil management in Pacific Islands; Investigating nutrient dynamics and the utility of soil information for better soil and farming system management. Pacific Soil Portal Phase 3, ACIAR /SLAM 2020/139

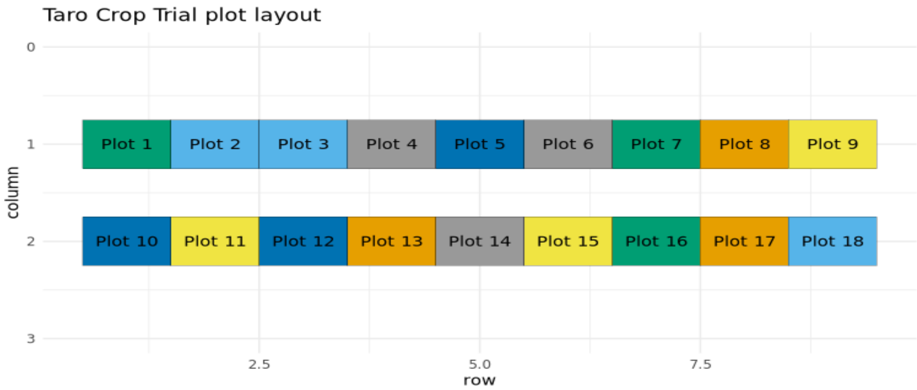
Introduction
Vaini on-farm trial implementation was known as Taro Trial project this project was on-going.
The Vaini on-farm trial's aim is to test the benefits of growing Taro with applying the fertilizer, NPK and Urea but apply on different rate of fertilizer.

Result
This is the method of applied fertilizer on different plots.

	Fertilizer Application				
Time of application	**Sowing – 0 months**				**2 months into taro crop growing**
Fertilizer type	**NPK (12:13:18)**		**Urea**		**Urea**
Plot 1	50 grams	+	3.5 grams		3.5 grams
Plot 2	50 grams	+	7 grams		NO Fertilizer
Plot 3	50 grams	+	7 grams		NO Fertilizer
Plot 4	50 grams	+	14 grams		NO Fertilizer
Plot 5	50 grams		NO Fertilizer		NO Fertilizer
Plot 6	50 grams	+	14 grams		NO Fertilizer
Plot 7	50 grams	+	3.5 grams		3.5 grams
Plot 8	50 grams	+	7 grams		7 grams
Plot 9	NO Fertilizer		NO Fertilizer		NO Fertilizer
Plot 10	50 grams		NO Fertilizer		NO Fertilizer
Plot 11	NO Fertilizer		NO Fertilizer		NO Fertilizer
Plot 12	50 grams		NO Fertilizer		NO Fertilizer
Plot 13	50 grams	+	7 grams		7 grams
Plot 14	50 grams	+	14 grams		NO Fertilizer
Plot 15	NO Fertilizer		NO Fertilizer		NO Fertilizer
Plot 16	50 grams	+	3.5 grams		3.5 grams
Plot 17	50 grams	+	7 grams		7 grams
Plot 18	50 grams	+	7 grams		NO Fertilizer

Close up of Plot 1 and 2 (Block 1) and Plot 10 and 11 (Block 2) that shows the taro planting density (5 x 4 plants) and spacing, as well as the area where samples will be harvested for measurements at harvest time within each plot (discontinued lines)





Recommendation

So, this project is still ongoing work on it until harvest next year. Continue on weeding and spray insecticide if there any plants affected by pest and disease.

source; week 9 Taro Trial Project

Refer for the photo above that's how it looks like the Taro Trial Project.

China Aid

China also provided assistance to help renovate and renew the roof of the laboratory. This support ensured that the facility was better protected from weather damage, allowing scientific work and experiments to continue safely without leaks or structural concerns. Not only that they also help on supply some of equipment are really help of doing soil sample use it new technology. The upgraded roof improves the overall durability and usability of the laboratory, supporting ongoing research and activities.

So, this the new equipment supplies by the China- Aid. It’s help a lot and build capacity of the co-workers on doing it for soil sampling.