Enhancing Guam's agriculture professionals' knowledge of ecological disease management

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INTRODUCTION

Cultivated plants are often grown outside their natural habitat making them prone to diseases and dependent on environmental amendments for maximum yields. The principle of ecological disease management is to reduce diseases or their impact by maintaining and enhancing the natural value of agricultural land by conserving its natural and environmental biological diversity through minimal inputs. Guam Cooperative Extension Service felt agriculture professionals in Guam and those in the Northern Mariana Islands could benefit from additional training in this area. In 2008, with the support of the WSARE grants program, a field plot was set up at the University of Guam's Western Pacific Tropical Research Center's Yigo Experiment Station to collection of data to be used in the development of a training manual for agriculture professionals. The manual will cover soil nutrient recommendations for the Mariana Islands, detection of soil nutrient deficiencies, and the principles of ecological disease management.

METHODS

Five plants of each crop were planted according to Guam Cooperative Extension recommendations into a non-replicated plant nutrient demonstration trial (Fig. 1). Data was collected from the inner three plants. Soil nutrient treatments were NPK, NPK plus micronutrients, deficient N plus PK, deficient P plus N K, and deficient K plus NP. Micronutrients were applied as a foliar spray to saturation of 20-20-20 Miracle-Gro™ at the rate of 2 ml / liter. The soil fertilizer included amendments: nitrogen at 120 lb/acre, P_2O_5 at 200 lb/acre and K_20 at 180 lb/acre. In 2009, deficiency levels were set at one quarter of the recommended levels. In 2010, the deficiency treatment received no additional nutrients, hot pepper was included as a crop, and the plant data was collected for the largest of the five plants.

Data collected included information on diseases, sugar content of fruits, soil pH, salinity, soil nutrients content, and plant biomass, height, yield, leaf count, tissue nutrient content, and chlorophyll levels. A variety of equipment was used for data collection and for training purposes. Spectrum Technologies Inc., Cardy-Nitrate and Cardy-Potassium meters were used to detect levels of NO_3^- and K^+ in petiole plant sap. The Cardy meter cleaning, calibration, and measurement procedures as outlined in the manufacturer's user guide were strictly followed. The SPAD-502 (Konica, Minolta, Japan) chlorophyll meter was used to measure the level of chlorophyll in crop leaves. The YSI 9500 photometer was used to measure various nutrients in petiole plant sap.

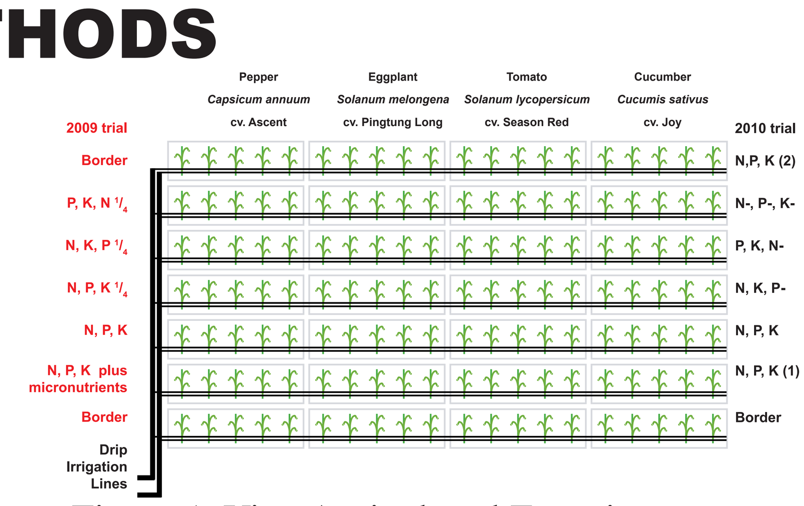

Figure 1. Yigo Agricultural Experiment Station field layout for soil nutrient deficiency demonstration plots for 2009 (red) and 2010 (black). Row spacing was 1 m. Plant spacing was 0.9 m for solanaceous crops and 0.3 for cucumber.

2010 UOG Soil Test

pH	7.3
% organic matter	7.0
P, ppm	11.0
K, ppm	8.2
Ca, ppm	578.0
Mg, ppm	9.0

Plot after transplanting, March 2009

RESULTS

The content of K^+ in the petiole sap of cucumber dropped sharply when soil nutrients were limited, with the lowest recorded in 2010 when the soil was not amended with K_20 (Table 1). Difference in K^+ concentration of sap between the NPK amended soil and others was small for eggplant, tomato and pepper, but large for eggplant in 2010 (Table 1). The content of NO_3^- in petiole plant sap was generally higher in soils with recommended levels of NPK across all crops and sampling times (Table 1). Generally, soil low in P had higher readings of NO_3^- than those soils that were low in K or N (Table 1). The SPAD-502 chlorophyll meter failed to detect any large or consistent differences in the 2009 trial (Fig. 3). The YSI 9500 photometer analysis of diluted fresh sap correlated highly with Cardy meter readings for K^+ and poorly with NO_3^- (Fig. 2). Visual examination of leaves of crops 4 WAT and 7 WAT produced none of the classic nutrient deficient symptoms (photos) despite a 50% or more reduction in yield.

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Photos of leaves of crops grown at the Yigo Agricultural Experiment Station in 2010 in soil amended with N, P, and/or K (black square = 1 in^2).

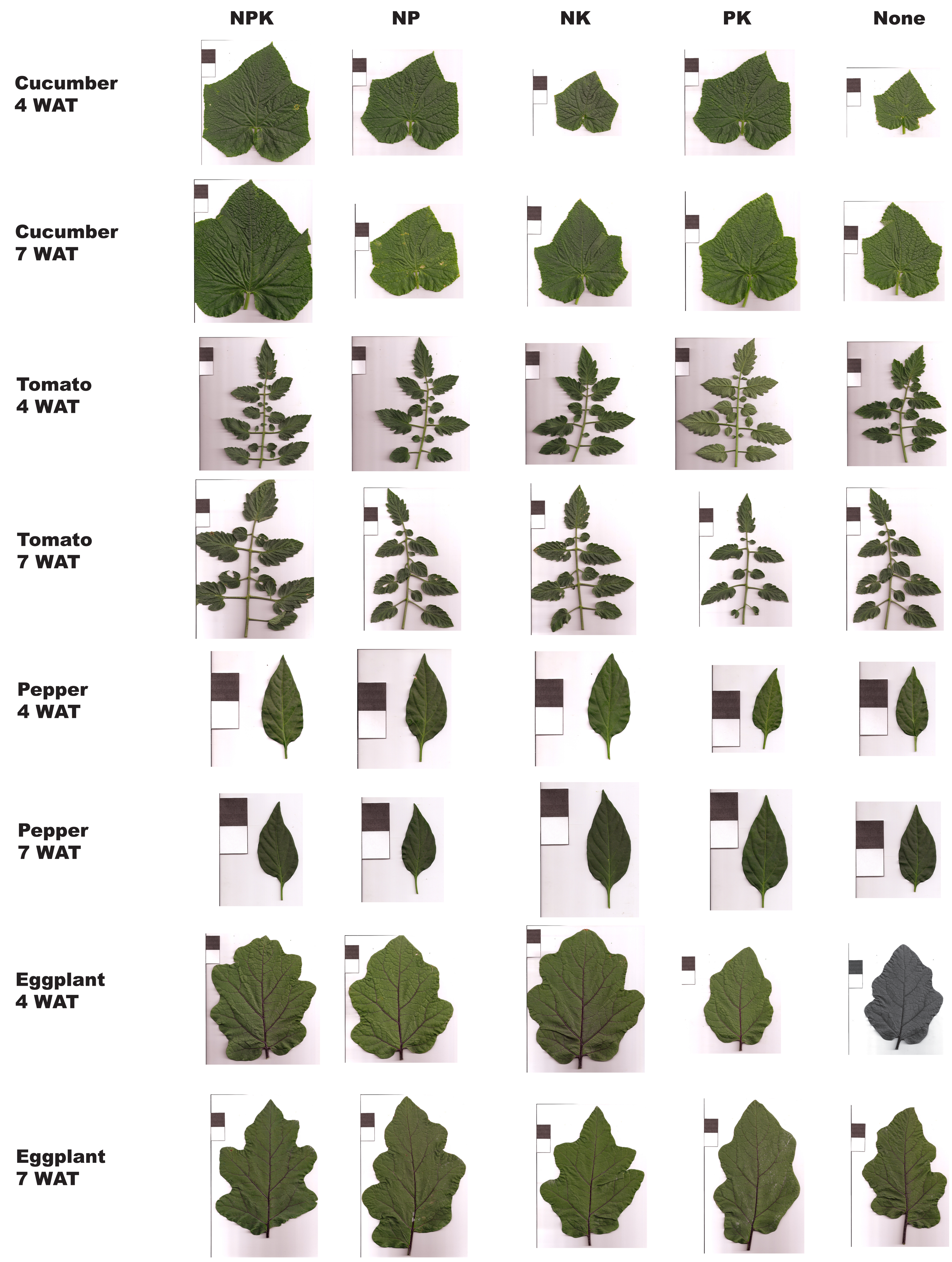

Table 1. NO_3^- and K^+ readings from the petiole sap analysis of cucumber, eggplant, tomato, and hot pepper planted at the Yigo Agricultural Experiment station in 2009 (red) and 2010 (black) between 4 to 10 weeks after transplant (WAT).

Cucumber	K^+	K^+	K^+	K^+	NO_3^-	NO_3^-	NO_3^-	NO_3^-	
Treatment 2009	4 WAT	4 WAT	6 WAT	5 WAT	4 WAT	5 WAT	7 WAT	7 WAT	Treatment 2010
P, K, N$^1/_4$	4600	3900	3700	4900	240	280	420	250	P, K, N-
N, K, P$^1/_4$	4000	2700	4000	4000	870	230	339	350	N, K, P-
N, P, K$^1/_4$	3900	1300	3100	960	590	200	230	300	N, P, K-
N, P, K	5300	3800	4300	4700	1100	380	230	600	N, P, K

Eggplant	K^+	K^+	K^+	K^+	NO_3^-	NO_3^-	NO_3^-	NO_3^-	
Treatment 2009	4 WAT	5 WAT	6 WAT	6 WAT	4 WAT	5 WAT	6 WAT	8 WAT	Treatment 2010
P, K, N$^1/_4$	4500	5000	3100	5600	928	680	380	660	P, K, N-
N, K, P$^1/_4$	4800	5800	3400	5800	973	1100	480	840	N, K, P-
N, P, K$^1/_4$	4200	2200	4100	2300	1084	860	450	720	N, P, K-
N, P, K	5000	6000	4400	6100	1040	1000	410	930	N, P, K

Tomato	K^+	K^+	K^+	K^+	NO_3^-	NO_3^-	NO_3^-	NO_3^-	
Treatment 2009	4 WAT	5 WAT	6 WAT	6 WAT	4 WAT	5 WAT	7 WAT	7 WAT	Treatment 2010
P, K, N$^1/_4$	2100	4700	1800	3900	402	390	407	230	P, K, N-
N, K, P$^1/_4$	2600	4600	2300	4100	622	620	249	510	N, K, P-
N, P, K$^1/_4$	2000	1200	1600	880	446	510	362	380	N, P, K-
N, P, K	2500	2000	2100	1500	624	N/A	475	280	N, P, K

Pepper	K^+	K^+	K^+	K^+	NO_3^-	NO_3^-	NO_3^-	NO_3^-	
Treatment 2009		7 WAT		10 WAT		7 WAT		10 WAT	Treatment 2010
P, K, N$^1/_4$	N/A	6200	N/A	5600	N/A	380	N/A	450	P, K, N-
N, K, P$^1/_4$	N/A	5800	N/A	4900	N/A	1100	N/A	980	N, K, P-
N, P, K$^1/_4$	N/A	6000	N/A	5100	N/A	1200	N/A	1400	N, P, K-
N, P, K	N/A	6200	N/A	5800	N/A	1300	N/A	1100	N, P, K

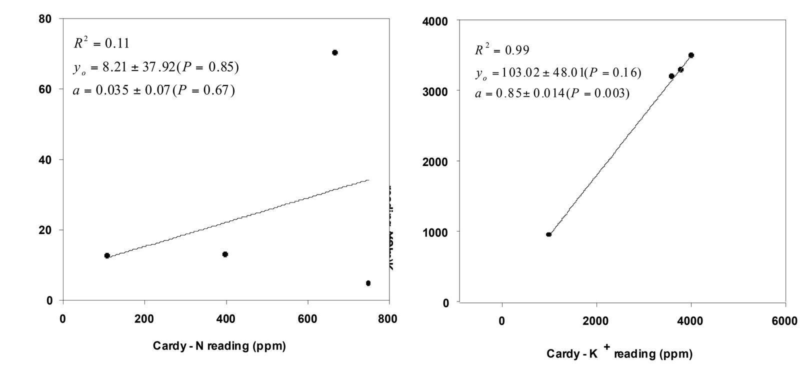

Fig. 2. Correlation between Cardy meter and YSI 9500 photometer readings of the content of cucumber petiole sap for NO_3^- (left) and K^+ (right) content.

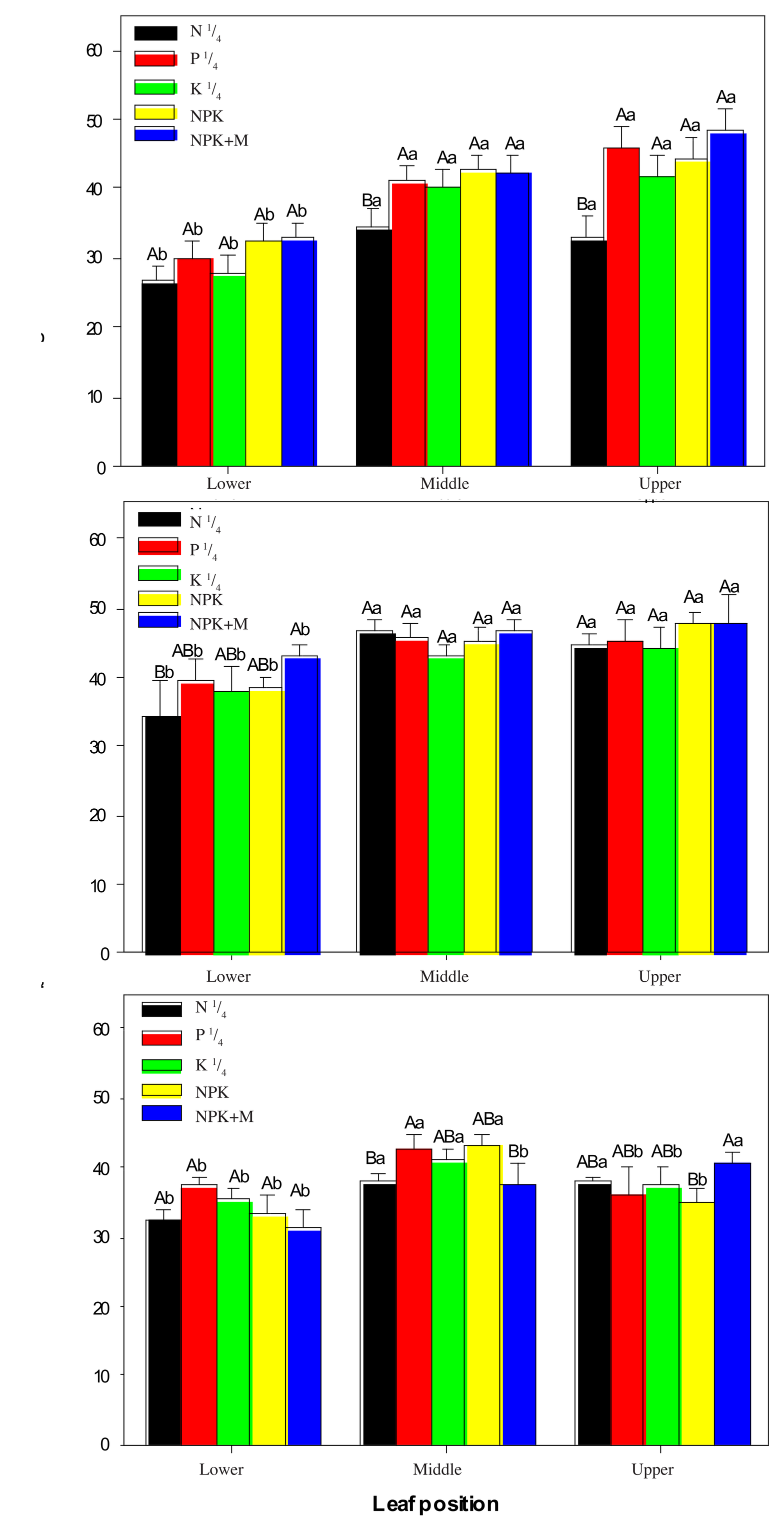

Fig. 3. Readings were recorded using the SPAD-502 chlorophyll meter from a) cucumber, b) eggplant and c) tomato across the lower, middle and upper leaf positions and five nutrient regime treatments: quarter applications of nitrogen ($N^1/_4$), phosphorus ($P^1/_4$) and Potassium ($K^1/_4$) as well as suggested rates of NPK and NPK + micronutrient. Bars represent LSD differences at P = 0.05. Capital letters refer to differences between treatments and small letters show differences between leaf positions.

DISCUSSION AND CONCLUSIONS

Analysis of the data indicates that a 75% reduction in recommended amounts of N, P, or K was sufficient to impact plant yield of cucumber, eggplant, and tomato and their height, leaf count, and biomass but not the development of diseases or visible distinct symptoms prior to plant senescence. The Cardy meters, YSI 9500 photometer, and SPAD-502 chlorophyll meter emerged as potential field instruments that can be used to detect nutrient deficiencies of solanaceous and cucurbit crops when exposed to extreme soil nutrient deficiencies. Hot pepper emerged as a crop that is tolerant of poor soil nutrient conditions, whereas cucumber proved to be highly dependent.