Comparative Analysis of Various Organic Nutrient Sources for Okra (*Abelmoschus esculentus*) Production

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Introduction

Organic farming for high-value crop production is gaining popularity mainly due to health awareness among common people and overall improvement of environmental sustainability. We recently developed a biofertilizer from cyanobacteria slurry which could potentially be considered as an alternative to chemical fertilizers used for crop production. However, high abundance of cyanobacteria in freshwater (harmful algal blooms; HABs) prevents sunlight penetration into the water and develops hypoxic conditions. Therefore, we removed cyanobacteria (physical method) from one of the lakes in Central Florida and utilized the resultant materials as biofertilizer for sustainable tomato production. Cyanobacteria biofertilizer provide macro and micro-nutrients in the soil and improve nutritional properties (antioxidant, anthocyanin, carotenoids, and chlorophyll contents) of vegetables. This short-term project also provided research experiences to a young scholar on organic agriculture.

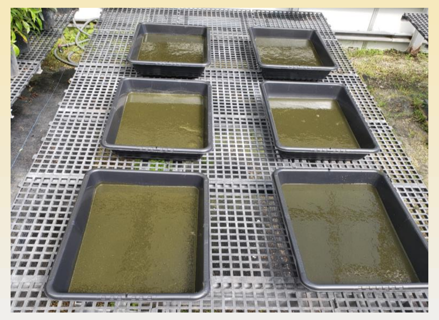
Objectives

This research experiment was planned to evaluate the performance of cyanobacteria biofertilizer and other organic nutrients sources for okra production in South Florida. Specific objectives of this study were:

1) Evaluate the effects of different organic fertilizers (chicken manure, vermicompost, and cyanobacteria fertilizer) and synthetic fertilizer (urea) on okra production and
2) Enhancement of knowledge and research experiences of pre-collegiate STEM student. Also, an aim to encourage women in science through this Young Scholar Enhancement (YES) grant.

Materials and Methods

- We collected cyanobacteria slurry from one of the lakes in Central Florida, processed as biofertilizer, and applied for high-value okra (var: Clemson spineless) production at the Organic Garden of the Florida International University (FIU). We found that solid matter content of the cyanobacterial mat was 16 to 18% of the total mass which was used for biofertilizer preparation.
- Four different treatments namely a) control (C; no fertilizer applied), b) synthetic fertilizers (SF; urea 46-0-0 and sulfate of potash 0-0-51 were applied), c) cyanobacteria biofertilizer (CB), and d) chicken manure (CM), e) and vermicompost (VM) were conducted in a randomized complete block design (RCBD) with six replications for each treatment. We used raised beds (228 x 76 cm^2) at the Organic garden for this study.
- Plant height (cm), stem diameter (cm), and leaf chlorophyll contents of okra plant from each plot were recorded at different crop growth stages and at harvesting. Crop was terminated at 70 days after seeding (DAS) and fruit yield was obtained by weighing harvested okra from each pot. Plant height and stem diameter (five readings from each plant) were measured using meter stick and slide calipers, respectively. Average leaf chlorophyll content of the developed upper leaves was recorded using the Soil-Plant Analyses Development (SPAD) 502 Plus Chlorophyll Meter.
- Fresh shoot and root samples were collected during harvesting.



Results and Discussion

- Nitrogen content in cyanobacteria biofertilizer was ranged from 1.56 to 1.94% and the C:N ratio (mol:mol) was in the range of 12:1 to 14: 1 (Table 1) which is narrower than composting commonly used in South Florida.
- Major micronutrients present in the biofertilizer were Fe (more than 2000 ppm) and Mg (1200 ppm).
- Average SPAD values of CB, CM, SF and VM plots were 1.25 to 1.28 times higher, than control (Figure 1).
- Plant heights of TS (98.4 cm) and TB (95.9 cm) were very similar to each other (not significantly different); however, both TS and TB had significantly higher plant height than control treatment. Plant height is an active indicator of vegetative growth or vigor of the plant. Cyanobacteria in the soil is capable to increase plant available P and other nutrients. The difference in plant biomass production of tomato under various treatments during week 7 is easily visible in Figure 2A.
- Pale-yellow leaf color (an interveinal chlorosis) and stunted growth were observed in some plants which is the possible indications of Fe deficiency. South Florida soils are deficient in Fe and the deficiency symptoms can be observed among plants received no fertilizer treatments (control pots). Comparing the treatments, no yellowing of leaves was observed in TB VM plots, likely resulted from high Fe contents (more than 2000 ppm) in the biofertilizer prepared from cyanobacteria (Table 1)

Table 1: Physicochemical properties of the soil and biofertilizer used for this experiment

Soil parameters

Parameters	Unit	Value
pH		8.01
Total C (TC)	%	6.07 ± 0.42
Total N (TN)	%	0.34 ± 0.06
Total P (TP)	ppm	103 ± 27
Potassium (K)	ppm	175 ± 42
Calcium (Ca)	ppm	13604 ± 2722
Magnesium (Mg)	ppm	255 ± 29
Sulphur (S)	ppm	79.20 ± 8.24
Zinc (Zn)	ppm	24.48 ± 5.69
Cupper (Cu)	ppm	32.80 ± 4.91
Sodium (Na)	ppm	51.73 ± 11.73

Properties of the Biofertilizer

Parameters	Unit	Value
Total C (TC)	%	19.56 ± 0.71
Total N (TN)	%	1.79 ± 0.07
Total P (TP)	%	0.02 ± 0.00
Total S (TS)	%	0.13 ± 0.01
Potassium (K)	%	0.06 ± 0.01
Calcium (Ca)	%	6.12 ± 0.70
Magnesium (Mg)	%	0.12 ± 0.01
Iron (Fe)	ppm	2005 ± 160
Manganese (Mn)	ppm	132.56 ± 13.35
Zinc (Zn)	ppm	53.34 ± 0.69
Cupper (Cu)	ppm	29.51 ± 4.80
Boron (B)	ppm	95.37 ± 4.21
Molybdenum (Mo)	ppm	1.82 ± 1.01
Nickel (Ni)	ppm	4.34 ± 1.78

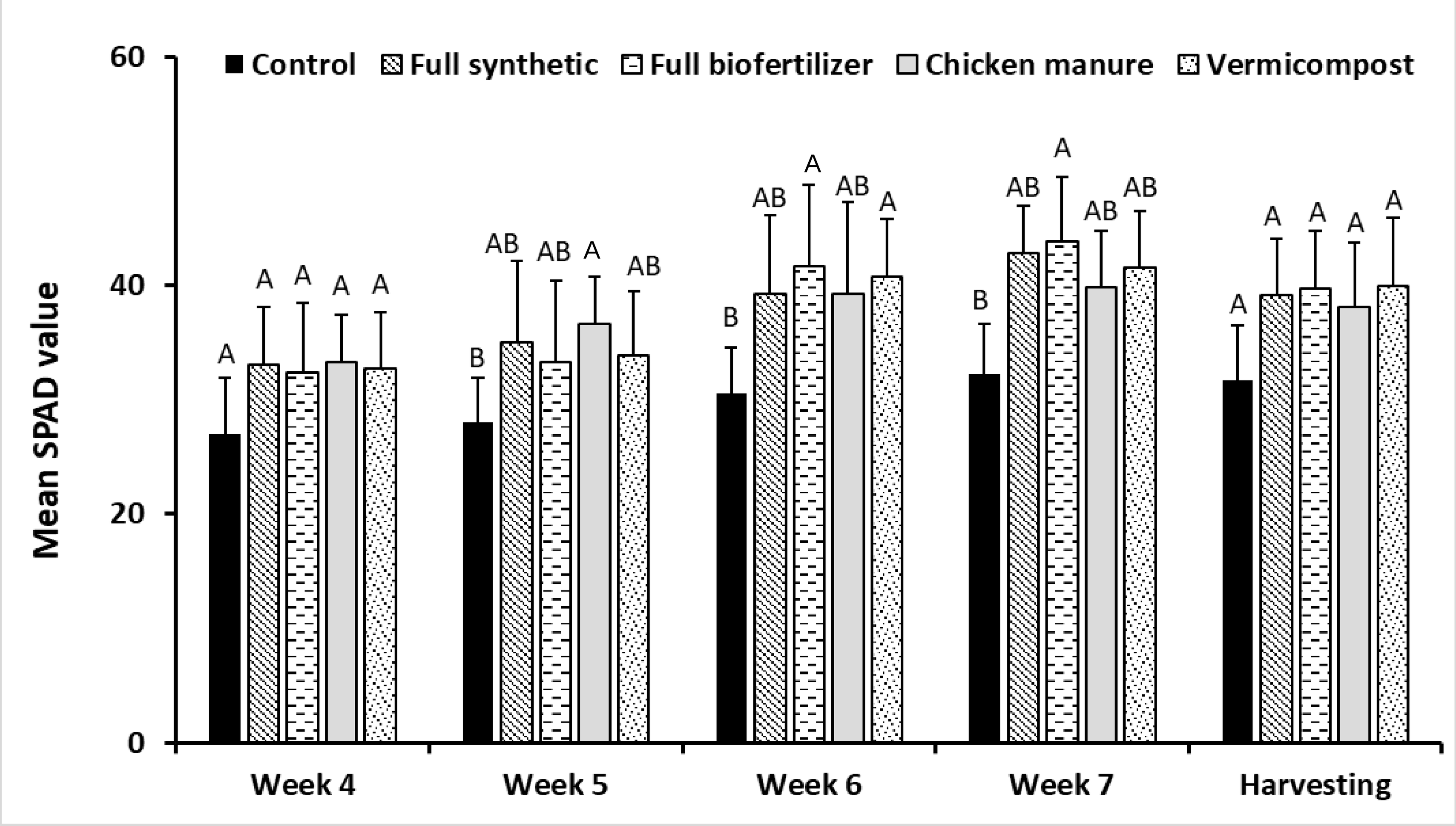


Figure 1: Soil Plant Analytical Development (SPAD) values of tomato plant at different growth stages

Biofertilizer

Synthetic

Control

Figure 2A: Visual representation of okra plants received different treatments: control, full synthetic fertilizer (TS), and cyanobacteria biofertilizer (CB)

Figure 2B: Visual representation of possible the experimental raised beds growing okra

- Average yield (gm per plant) of SF, CB and VM were higher than control (Table 2). A common advantage of using biofertilizer is the addition of lot of plant growth regulators and hormones to the soil.
- Even for a shorter study (for about 70 days) the amount of C (10.77%) and N (0.53%) contents in soils at TB pots at harvesting (data not presented here) were significantly higher than control pots (C, 5.46% and N, 0.30%). Mg which is a major component of chlorophyll was also significantly higher in TB pots than other treatments.

Table 2: Physiological parameters and yield of tomato under different treatments

Treatments	Plant height*	Stem diameter*	Shoot dry weight¶	Root dry weight*	Shoot:Root	Yield¶
	cm	cm	g			g/pot
Control	45.3 ± 3.68 b	0.78 ± 0.08 b	26.71 ± 4.61 b	5.61 ± 0.88 b	4.69	73.38 ± 5.27 b
SF	62.8 ± 4.81 a	1.08 ± 0.16 ab	47.92 ± 6.99 ab	8.37 ± 1.95 ab	6.14	120.98 ± 9.42 a
CB	61.3 ± 5.16 a	1.11 ± 0.13 ab	55.01 ± 7.62 a	11.58 ± 2.16 a	4.75	130.34 ± 8.78 a
CM	58.3 ± 3.68 a	1.05 ± 0.13 ab	37.07 ± 3.92 ab	7.59 ± 0.78 ab	4.21	110.18 ± 12.36 ab
VM	64.8 ± 4.69 a	1.20 ± 0.23 a	59.02 ± 6.92 a	11.09 ± 1.78 a	5.32	125.04 ± 11.12 a

Where SF = synthetic fertilizer; CB = cyanobacteria biofertilizer; CM = chicken manure and VM = vermicompost

*Similar letters indicate no significant difference at $p<0.10$

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