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Optimizing N Input Rate for Selected Asian Vegetable Production (luffa and long bean) in Florida©

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SUMMARY

There are more than 40 types of Asian vegetable crops grown in Florida. Recommendations for nitrogen (N) fertilization are being developed by UF/IFAS for Florida growers. Nitrate leaching is common in Florida due to the combination of sandy soils and high precipitation. Growers commonly over-fertilize with N as an insurance for high yield, which can negatively affect the environment and production costs. The objective of this study was to determine the optimal N fertilizer input rates for luffa (*Luffa acutangula*) and long bean (*Vigna unguiculata*) under conventional production in Florida. Our research shows that maximum yield occurred at N rates of 171 and 227 kg.ha^{-1} (150 and 200 lb.ac^{-1}), respectively, for luffa and long bean.

Keywords: Asian vegetables, environment, health, *Luffa acutangular,* N input, *Vigna unguiculata* , yield

INTRODUCTION

Nitrogen (N) is an essential element that is critical for amino acid synthesis, and is taken up by plants as ammonium or nitrate. Applying N at the optimal rate is critical to maximize yield and profit. Insufficient N inputs will negatively affect plant growth and production (Wang, Li, and Bai, 2017). Over fertilization with N also inhibits infection and enzyme activity in N fixation (Fahraeus and Ljunggren, 1959; Sloger, 1976). Nitrogen inputs above or below the optimal rate decrease yield (Wang, 2018), and N fertilization can also affect fruit quality and nutritional value. High N inputs decrease the ascorbic acid concentration of fruit (Rajasree & Pillai, 2012), and can increase concentrations of carcinogenic N-nitroso from nitrate, as vitamin C is an inhibitor of this process (Mozafar, 1993). Since most soils in Florida are sandy, N fertilizers are prone to leaching due to low soil organic matter content, low cation exchange capacity, and high infiltration rate (Wetselaar 1962). This can be exacerbated by high summer precipitation.

Luffa (*L. acutangula*) is an annual vine in the cucurbit family that is adapted to hot and humid environments (Herklot, 1972; Purseglove, 1968). Long bean (*Vigna unguiculata* subs. *sesquipedalis*) is an annual vine in the legume family that is a good N-fixer, especially during blooming (Huang, Cai, Lv, Wu, & Cai, 1983). It is resistant to hot, dry, and infertile soils, which makes it more adaptive than most beans (Wang et al., 2013).

Both of these Asian vegetables are increasingly popular in Florida (Liu et al., 2015; Xie, Liu, Li, and Migliaccio, 2016). These new vegetables, along with 40 other species, enhance the diversity of vegetable markets. They are popular in Asian grocery stores in the U.S especially in California, New York and Florida (Xie, Liu, Li, & Migiaccio, 2016). In addition to nutritional benefits for customers, Asian vegetables are also more profitable for growers than traditional commodities. However, there is no official recommendation for N fertilization for Florida growers, even though UF/IFAS publishes a handbook (Agehara et al., 2019) every year on dozens of other vegetables. The objective of this study is to determine the optimal nitrogen fertilizer input rate for luffa and long bean under conventional production in Florida.

MATERIALS AND METHODS

Experimental Design. A field trial was conducted from March to July 2019 at the University of Florida Plant Science Research and Education Unit (PSREU) in Citra, Florida. Four treatments were established in a randomized block design: [0, 114, 171 and 227 $kgN.ha^{-1}$ (0, 100, 150 and 200 $lbs.N.ac^{-1}$)], with four replicate plots per treatment, ten plants per plot. Plants were fertigated with NH_4NO_3, along with 171 $kgP.ha^{-1}$ (150 $lbs.P.ac^{-1}$), applied twice a week via drip irrigation during a 10-week fertigation schedule.

In each plot, luffa (*Luffa acutangula* ‘Jiao Gua’) and yardlong bean (*Vigna unguiculata* subs. *sesquipedalis* ‘Bai-lung’) (Tainong Seed Co.) seeds were sown in the field on 19 March 2019. Seedlings were thinned to 10 plants per plot on 5 April 2019. Plants were irrigated twice per day throughout the trial: two hours in the morning and one hour in the afternoon.

Data collection. Three soil samples [0-30.5 cm (0-12 in.)] were collected for nitrate analysis before planting, 63 days and 110 days after planting and analyzed for NO_3-N concentration (Waters Agriculture Laboratory, GA). Thirty leaf samples per plot were collected at three growth stages: 7.6 cm (3-in.) long fruit, first harvest, and mid-harvest to measure leaf greenness (SPAD 502) and petiole sap NO_3 content (Horiba LAQUA NO_3

Meter). From 16 May 2019 until 7 July 2019, crops were harvested every 4-7 days. Long bean pods were weighed and luffa fruit were counted and weighed for yield. At the end of the season, thirty plants per plot were sampled and separated into blade, petiole and stem, dried at 65 ˚C for 21 days and analyzed for total N (Waters Agriculture Laboratory, GA).

Data analysis. The data were calculated for treatment means and standard errors in Microsoft Excel. All quantitative data except for yield were analyzed using analysis of variance using SAS software (9.4 TS Level 1M6 X64-DSRV16 platform) and significant differences between means were determined using Tukey's test at $P < 0.05$.

RESULTS

SPAD readings. When luffa fruit were 7.6 cm (3-in.) long, there were no significant differences in SPAD readings among the four N treatments during the three measurement periods (Table 1). With long bean, only on 21 May 2019 were there significant differences using the Tukey Test. The 114 $kgN.ha^{-1}$ (100 lb. $N.ac^{-1}$) had a higher SPAD reading than the 0 or 171 $kgN.ha^{-1}$ (0 or 150 lb. $N.ac^{-1}$).

Petiole sap NO_3. Luffa treated with 171 $kgN.ha^{-1}$ (150 lb. $N.ac^{-1}$) has the highest petiole sap NO_3 throughout the reproductive stage, except for the final sampling period (17 June 2019), when there were no significant treatment differences with the Tukey test (Table 2). With Luffa, there were no significant differences in petiole sap NO_3 among 0, 114 or 227 $kgN.ha^{-1}$ (0, 100 or 200 lb. $N.ac^{-1}$). There was trend in petiole sap NO_3 being lowest during the last measurement period: 17 June 2019. With long bean, 171 $kgN.ha^{-1}$ (150 lb. $N.ac^{-1}$) had the highest petiole sap NO_3 during the first sampling period, compared to the nonfertilized control (Table 2). There were no significant differences among treatments during the middle and final sampling period. As with Luffa, there was trend in declining petiole sap NO_3 during the final sampling period (Table 2). For long bean, there was a trend with plants at 171 $kgN.ha^{-1}$ (150 lb. $N.ac^{-1}$) having the highest petiole sap NO_3 - when fruit was 7.6 cm (3-in.) long and at first harvest. There was a trend with long bean plants grown in control plots having the lowest petiole sap NO_3 value.

Soil sampling. Background soil NO_3-N content was low in all four blocks (data not shown). After 63 days (2nd soil sample), long bean fertilized with 171 $kgN.ha^{-1}$ (150 lb. $N.ac^{-1}$) had the highest soil NO_3-N; there was a similar trend with Luffa (Table 3). After 110 days (3rd soil sample) long bean receiving 227 $kgN.ha^{-1}$ (200 lb. $N.ac^{-1}$) had the highest soil NO_3-N content, while there was a similar trend in Luffa at the highest N-fertility level (Table 3)

Daily fruit number and yield. The highest luffa yields were recorded with 227 $kgN.ha^{-1}$ (200 lb. $N.ac^{-1}$) during first harvest, 114 $kgN.ha^{-1}$ (100 lb. $N.ac^{-1}$) at mid-harvest or 171 $kgN.ha^{-1}$ (150 lb. $N.ac^{-1}$) at the mid to final harvest (Fig. 1a,b). Control plots of both species always had the lowest yields (Fig. 1a,b,c). Before May 28, long bean yields were highest with 171 $kgN.ha^{-1}$ (150 lb. $N.ac^{-1}$), whereas after June 11, plants treated with 227 $kgN.ha^{-1}$ (200 lb. $N.ac^{-1}$), had the highest yield (Fig. 1c). Yields decreased with lower N inputs (Fig. 1c).

Plant tissue N. For stem and petiole tissue, there was no difference in total N concentration among different N input treatments for both luffa and long bean (Fig.2 a,b). There was a trend in highest total N concentration in luffa leaf blades at 171 $kgN.ha^{-1}$ (150 lb. $N.ac^{-1}$); however there were no significant differences in leaf blade total N among the four N treatments. With long bean, leaf blade N was highest with 171 $kgN.ha^{-1}$ (150 lb. $N.ac^{-1}$) and lowest at the control / 0 N treatment (Fig. 2b).

DISCUSSION

In this study we measured the effect of nitrogen fertilization levels by monitoring the leaf chlorophyll content via SPAD readings, tissue N content and soil N levels along with yield of vegetables. Although luffa and yard long bean share similar growth habits, long bean is a known nitrogen fixer while luffa is not. Hence, we hypothesized that these two vegetable crops could require different levels of N input for optimal yields. Luffa had the highest yield and similar N content in the leaf blade with 171 $kgN.ha^{-1}$ (150 lb. $N.ac^{-1}$) compared to 227 $kgN.ha^{-1}$ (200 lb. $N.ac^{-1}$). This is consistent with delayed flowering and yield reported by Dai et al. (2011). Nitrogen fertilizers can alter plant hormones and promote female flowers and reduce male flowers (Omini and Hossan, 1987). Furthermore, N greatly affects dry mater partitioning (Dai et al., 2011), which may reduce fruit production - given the extended co-existence of vegetative and reproductive development in cucurbits (Zhang et al., 2018). Thus, keeping a good balance of N sources and sinks via adequate fertilization is important to reach maximum yield (Dai et al., 2011; Tanemura, Kurashima, Ohtake, Sueyoshi, & Ohyama, 2008).

For long bean, 227 $kgN.ha^{-1}$ (200 lb. $N.ac^{-1}$) had the highest yield, and trends in greater petiole sap NO_3-N, leaf greenness, and soil NO_3 in the mid-late season. This is consistent with research by Wang, Li, and Bai (2017) who reported that in long bean as N fertilizer decreased - leaves were light green and stunted, as were vines; with increased N inputs, leaves were dark green and growth of vines and leaves were vigorous. The 171 $kgN.ha^{-1}$ (150 lb. $N.ac^{-1}$) treatment had the highest petiole sap NO_3 at first leaf sampling, which could be explained by long bean's greater N-fixation capacity during blooming (Huang, Cai, Lv, Wu, and Cai, 1983). Since NO_3 inhibits infection and enzyme activity in N fixation (Fahraeus and Ljunggren, 1959) and NH_4 decreases nodulation and N fixation by inhibiting Rhizobium (Sloger, 1976) -this could account for the lower yield of long bean with 227 $kgN.ha^{-1}$ (200 lb. $N.ac^{-1}$) during early harvests. However, we did not check for root nodules in long bean plants in the field.

The SPAD readings did not show any significant difference between treatments within the measuring stages except for long bean on 21 May 2019. These may due to sampling errors. In our experiment, the SPAD readings were not relevant for identifying N deficiency.

This study provides preliminary guidance to establish N input recommendations for Florida Asian vegetable growers. Greatest yield occurred at 171 and 227 $kgN.ha^{-1}$ (150 and 200 lb. $N.ac^{-1}$), respectively, for luffa and long bean. Future field trials will be conducted during the fall 2019. This is the first study focusing on N inputs in luffa and long bean production in Florida, which enhances our knowledge of best management practice for selected Asian vegetables in Florida. Future steps of this research will focus on the effect of N inputs on fruit quality, nitrogen use efficiency, and rhizobium of long bean.

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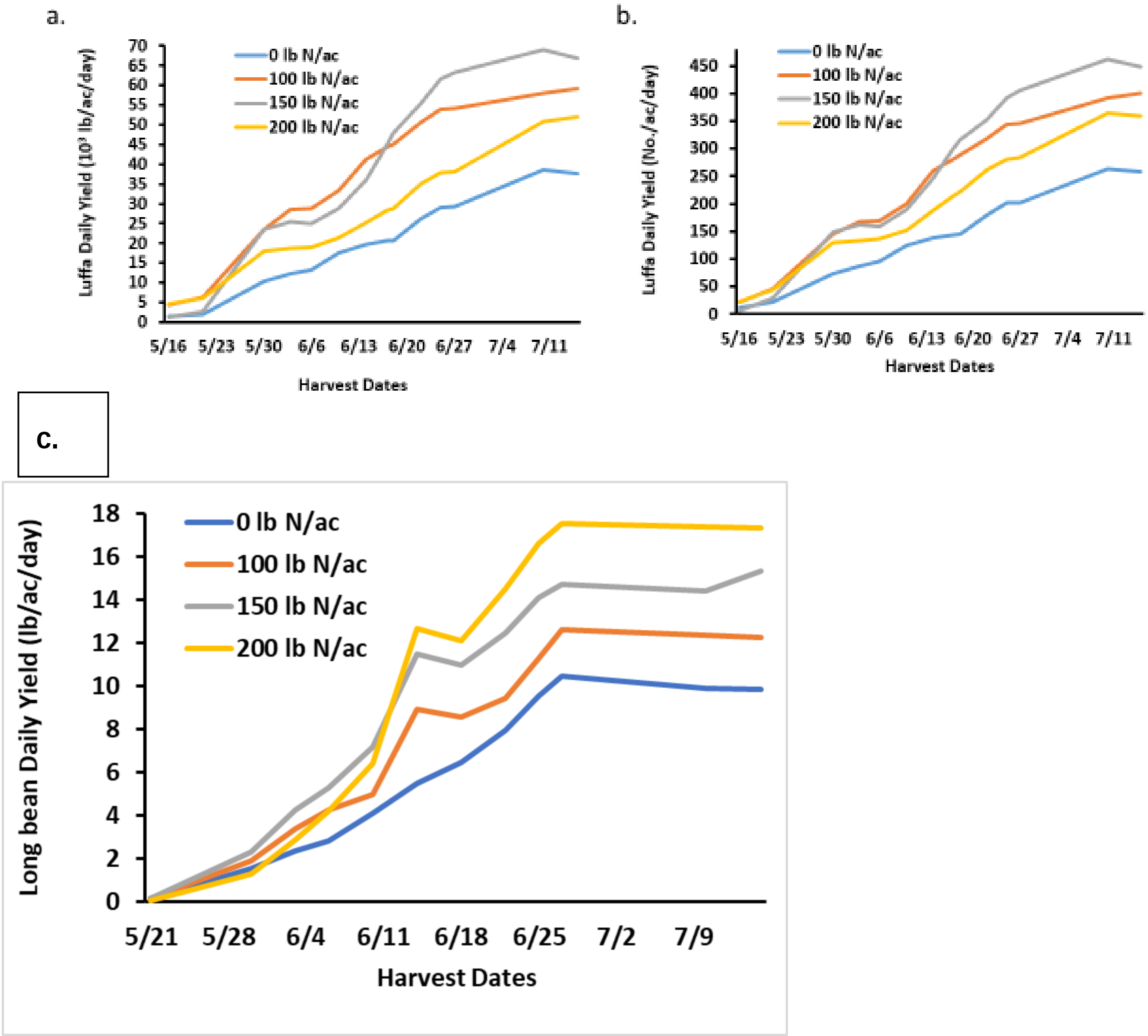
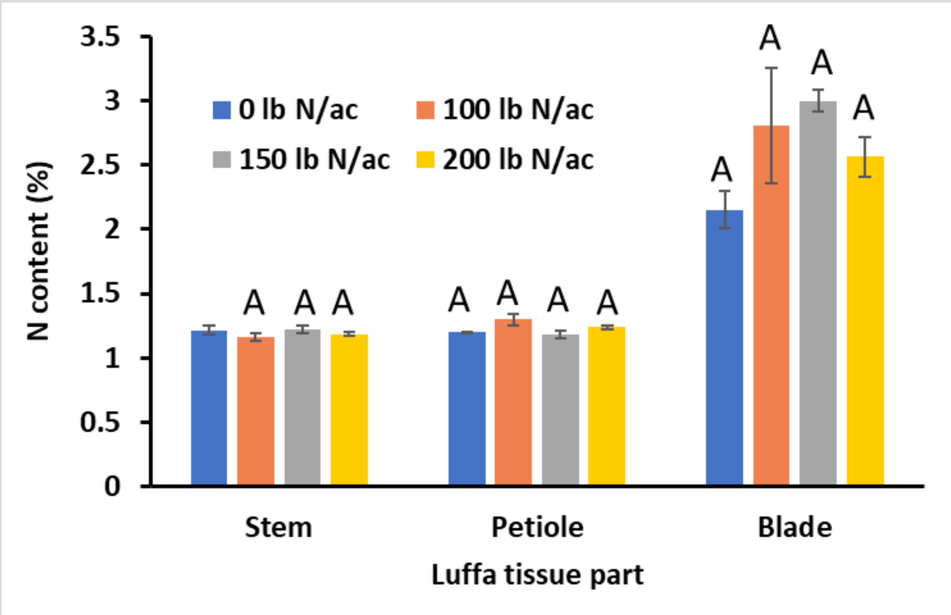


Figure 1. (a) Daily yield (10^3 lb./ac/day) of luffa fruits, (b) number of luffa fruits, and (c) daily yield of long bean pods (lb./ac/day).

(A) Luffa



(B) Long Bean

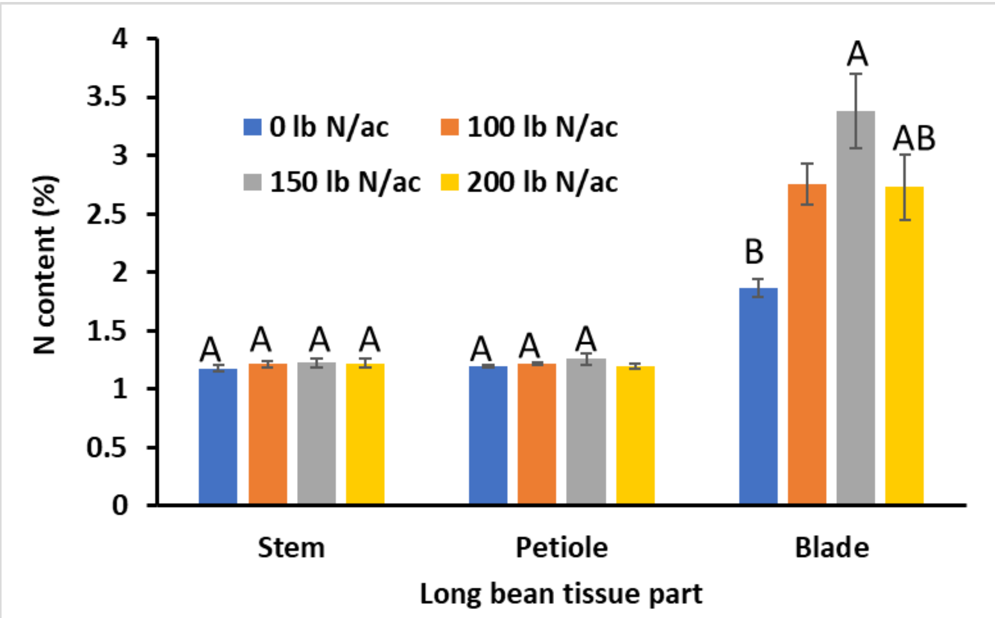


Figure 2. Plant tissue (stem, petiole, blade) analysis of total N content (%) of (a) luffa and (b) long bean plants. The bars represent the mean and standard error from four values each from individual plot. The data are compared within each tissue group. Data marked by the same letters are not significantly different from each other using Tukey's test at $P < 0.05$.

Figure 3. The field trial including long bean and luffa plants during the vegetative stage.

Figure 4. Luffa plants (left) in the reproductive stage.

Figure 5. Long bean plants in the reproductive stage.

Table 1. SPAD reading. Data collected on the same day of each crop were analyzed as one set. Data marked by the same letters are not significantly different from each other using Tukey's test at $P < 0.05$.

	Luffa			Long bean		
	05/04/2019	05/21/2019	06/03/2019	05/04/2019	05/21/2019	06/03/2019
0 lb. N/ac	36.6±1.6 a	35.8±0.3 a	42.5±0.7 a	47.4±0.4 a	52.9±0.2 b	55.8±0.6 a
100 lb. N/ac	38.8±0.7 a	38.2±0.2 a	42.8±0.5 a	48.1±0.8 a	57.3±0.5 a	58.4±0.7 a
150 lb. N/ac	37.2±0.5 a	37.8±0.6 a	42.8±0.4 a	50.5±1.7 a	53.1±0.9 b	58.7±1.0 a
200 lb. N/ac	37.3±0.1 a	38.8±0.5 a	39.9±0.7 a	52.2±2.1 a	54.5±1.0 ab	60.4±1.5 a

Table 2. Petiole sap NO_3 content (ppm). Data collected on the same day of each crop were analyzed as one set. Data marked by the same letters are not significantly different from each other using Tukey's test at $P < 0.05$.

	Luffa			Long bean		
	05/21/2019	06/06/2019	06/17/2019	05/21/2019	06/06/2019	06/17/2019
0 lb. N/ac	1025±103 b	1035±54 b	543±36 a	725±26 b	805±36 a	625±48 a
100 lb. N/ac	733±73 b	733±72 b	637±12 a	1663±210 ab	933±37 a	988±91 a
150lb. N/ac	1800±114 a	2300±239 a	760±99 a	1833±284 a	1220±112 a	823±32 a
200 lb. N/ac	797±25 b	910±85 b	673±48 a	1433±227 ab	950±47 a	1093±92 a

Table 3. NO_3-N (ppm) content for the two in-season soil sampling 63 days and 110 days after planting. The 2nd sampling was during the fertigation treatment, and the 3rd sampling was after the fertigation. Soil NO_3-N content before the experiment began, averaged across four blocks, was 0.1 ppm. Data collected on the same time of each crop were analyzed as one set. Data marked by the same letters are not significantly different from each other using Tukey's test at $P < 0.05$.

	2nd soil sample		3rd soil sample	
	Long bean	Luffa	Long bean	Luffa
0 lb. N/ac	0.24±0.01 c	0.31±0.11 a	1.01±0.35 b	0.46±0.03 a
100 lb. N/ac	1.01±0.18 b	0.68±0.05 a	1.40±0.15 b	0.32±0.07 a
150 lb. N/ac	2.65±0.30 a	1.40±0.30 a	1.74±0.16 ab	0.32±0.06 a
200 lb. N/ac	1.44±0.18 b	0.32±0.08 a	3.09±0.43 a	2.26±0.46 a