

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

Yanlin Wang¹, Gabriel Maltais-Landry², Bala Rathinasabapathi¹, Steven A. Sargent¹ and Guodong Liu¹

¹Horticultural Sciences Department, 2550 Hull Road, PO Box 110690, University of Florida, Gainesville, Florida 32611, USA; ²Soil and Water Sciences Department, McCarty Hall A, University of Florida, Gainesville, Florida 32611, USA

guodong@ufl.edu

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

Abstract

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.

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, & Migliaccio, 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 NH₄NO₃, 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 NO₃-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 NO₃ content (Horiba LAQUA NO₃ 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).

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

Petiole sap NO₃

Luffa treated with 171 kgN.ha⁻¹ (150 lb. N.ac⁻¹) has the highest petiole sap NO₃ 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 NO₃ among 0, 114 or 227 kgN.ha⁻¹ (0, 100 or 200 lb. N.ac⁻¹). There was trend in petiole sap NO₃ 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

NO₃ 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 NO₃ 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 NO₃ - 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 NO₃ value.

Table 2. Petiole sap NO₃ 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

Soil sampling

Background soil NO₃-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 NO₃-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 NO₃-N content, while there was a similar trend in Luffa at the highest N-fertility level (Table 3).

Table 3. NO₃-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 NO₃-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

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).

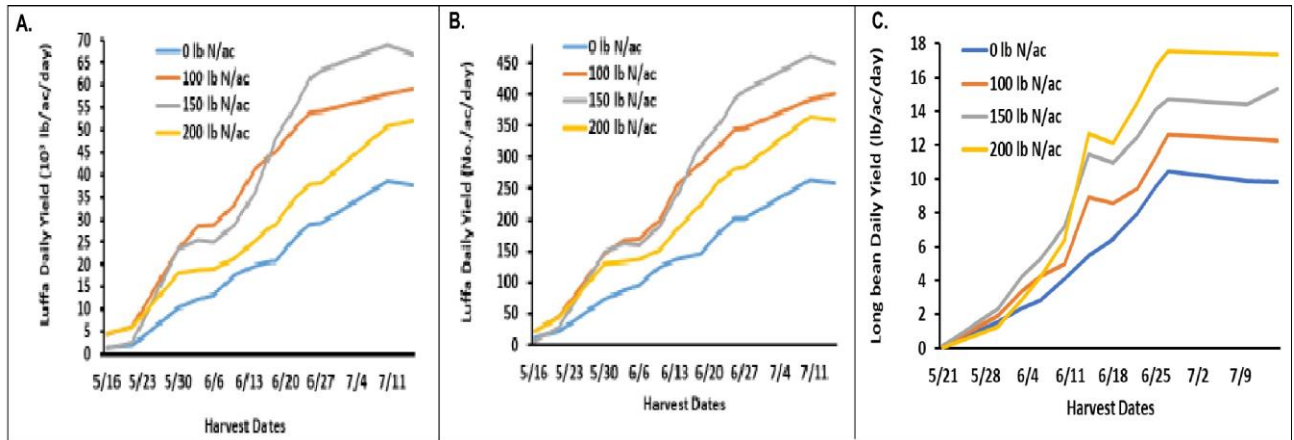


Figure 1. (a) Daily yield (10³ lb./ac/day) of luffa fruits, (b) number of luffa fruits, and (c) daily yield of long bean pods (lb./ac/day).

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).

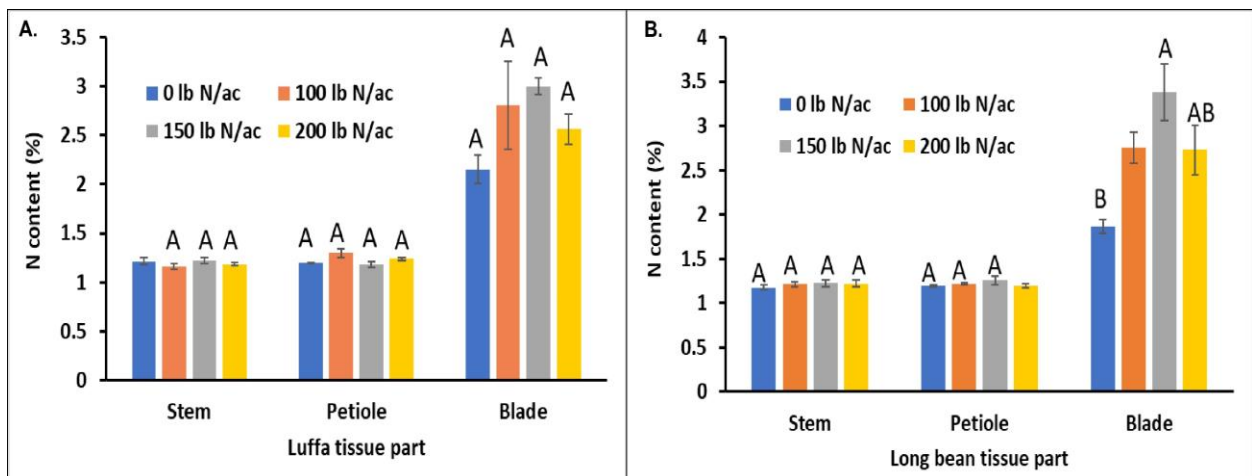


Figure 2. Plant tissue (stem, petiole, blade) analysis of total N content (%) of (a) luffa and (b) long bean plants. The bars represent the mean and standard error from four values each from individual plot. The data are compared within each tissue group. Data marked by the same letters are not significantly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

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} ($150 \text{ lb. N.ac}^{-1}$) compared to 227 kgN.ha^{-1} ($200 \text{ lb. N.ac}^{-1}$). 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 matter 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} ($200 \text{ lb. N.ac}^{-1}$) had the highest yield, and trends in greater petiole sap $\text{NO}_3\text{-N}$, 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} ($150 \text{ lb. N.ac}^{-1}$) 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} ($200 \text{ lb. N.ac}^{-1}$) 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 $200 \text{ lb. N.ac}^{-1}$), 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.

Literature Cited

- Agehara, S., Beuzelin, J., Boyd, N. S., Desaegeer, J., Dittmar, P. J., Dufault, N. S., and Zotarelli, L. (2019). Vegetable Production Handbook of Florida, 2019–2020 edition. Gainesville, FL.
- Dai, J., Liu, S., Zhang, W., Xu, R., Luo, W., Zhang, S., and Chen, W. (2011). Quantifying the effects of nitrogen on fruit growth and yield of cucumber crop in greenhouses. *Scientia Hort*, 130: 551-561.
- Fahraeus, G. and Ljunggren, H. (1959). The possible significance of pectic enzymes in root hair infection by nodule bacteria. *Physiol. Plant*. 12:145-154.
- Herklots G.A.C. (1972). Vegetables in south-east Asia. London: Allen and Unwin, pp. 326- 329, 333-338.
- Huang, W., Cai, K., Lv, R., Wu, Y., and Cai, N. (1983). The intercropping green manure in citrus orchard—the evaluation of nitrogen fixation activity and amount of Indian long bean nodule. *Journal of Fujian Agriculture and Forestry University (Natural Science Edition)*, 4.
- Liu, G., Wang, Q., Li, Y., Dinkins, D., Wells, B., and Khatri, K. (2015). Long Bean—an Asian vegetable emerging in Florida. EDIS. Retrieved from <http://edis.ifas.ufl.edu/hs1268>
- Mozafar, A. (1993). Nitrogen fertilizers and the amount of vitamins in plants: a review. *J. Plant Nutrit*. 16:2479-2506.
- Omini M.E., Hossain, M.G. (1987). Modification of sex expression in sponge gourd (*Luffa cylindrica* L.) Roem by mineral nutrient treatments. *Genetica* 74: 203-209.
- Purseglove, J.W. (1968). Tropical crops – dicotyledons. London: Longman. Pp. 128- 134.
- Rajasree, G. and Pillai, G. R. (2012). Effect of nitrogen nutrition on fruit quality and shelf life of cucurbitaceous vegetable bitter gourd. *J. Plant Nutrit*. 35: 1139-1153.
- Sloger, C. (1976). Biochemistry of N₂ fixation. *World soybean research*. L. D. Hill (Ed.). Danville: The Interstate printers and publishers Inc., III. Pp. 125-135.
- Tanemura, R., Kurashima, H., Ohtake, N., Sueyoshi, K., and Ohyama, T. (2008). Absorption and translocation of nitrogen in cucumber (*Cucumis sativus* L.) plants using the 15N tracer technique. *Soil Sci. Plant Nutrit*. 54: 108-117.
- Wang, T., Li, C., and Bai, Z. (2017). The report of nitrogen (N) fertilization for yard long bean trial in Dengjiang County in 2013. *Nong Ming Zhi Fu Zhi You*, 4:131-136.
- Wetselaar, R. (1962). Nitrate distribution in tropical soils. III. Downward movement and accumulation of nitrate in the subsoil. *Plant Soil* 16: 19-31.
- Xie, Y., Liu, G., Li, Y., and Migliaccio, K. (2016). Luffa—an Asian Vegetable Emerging in Florida. EDIS. Retrieved from <http://edis.ifas.ufl.edu/hs1285>
- Zhang, B., Li, M., Li, Q., Cao, J., Zhang, C., Zhang, F., and Chen, X. (2018). Accumulation and distribution characteristics of biomass and nitrogen in bitter gourd (*Momordica charantia* L.) under different fertilization strategies. *J. Sci Food* 98: 2681-2688.