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EFFECT OF NITROGEN ON GROWTH AND YIELD OF OKRA VARIETIES (*Abelmoschus esculentus* L.) GROWN IN THUA THIEN HUE

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Abstract. The experiments were conducted in a three-replicate split-plot design of 2 × 4 treatments, with variety as the main plot and nitrogen fertilizer application as the sub-plot. Four nitrogen rates: 60, 90, 120, and 150 kg/ha and two varieties: the local variety and the F1 variety, were investigated. The results show that nitrogen significantly affects the stock diameter at 37-day planting, fruit diameter, length, number per plant, weight, theoretical yield, and actual yields of both varieties. However, the interaction between fertilizer and variety is insignificant for all parameters. Nitrogen fertilizer at 150 kg/ha increases the plant height, the number of leaves per plant, and the yield of both varieties, whereas the 60 kg/ha rate shows the lowest value of these traits. More diamondback moths and Green worms are found on the F1 variety than that on the local variety. Nitrogen does not affect the pests that harm the plants of the F1 variety. It is recommended to apply 150 kg/ha of nitrogen for okra grown in the Winter-Spring season.

Keywords: nitrogen, okra, yield, growth

1 Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) or lady's finger is an annual vegetable cultivated in numerous tropical and sub-tropical regions. The young immature okra pod is consumed as nutritional food in a variety of ways (fresh or boiled, dried or fried), and the seed is used to produce oil. The oil contains healthy components, such as vitamins, flavonoid antioxidants, calcium, potassium, and other minerals [1]. The composition of okra pods per 100 g edible portion (81% of the product as purchased, ends trimmed) is as follows: water 88.6 g, energy 144 kJ (36 kcal), protein 2.1 g, carbohydrate 8.2 g, fat 0.2 g, fibre 1.7 g, Ca 84 mg, P 90 mg, Fe 1.2 mg, β-carotene 185 μg, riboflavin 0.08 mg, thiamin 0.04 mg, niacin 0.6 mg, and ascorbic acid 47 mg [2]. The extract of young okra pods is not only used as a thickening agent for soups or sauces but also displays moisturizing and diuretic properties [3, 4]. This extract is reported to have anti-hyperglycemic effects on diabetes [5]. Okra seeds contain a lot of oil and protein and can be used as a non-caffeinated substitute for coffee [1, 6]. They are reported to possess anticancer and fungicidal properties [4]. The okra pod can be harvested regularly and continuously. Because of

these valuable benefits and simple cultivation, okra is grown widely in family gardens. Furthermore, okra is a vegetable that could increase income for small producers [7]. Recently, farmers of Thua Thien Hue province have grown vegetables of high economic value, such as okra, pennywort, and netted melon. To grow okra, farmers often use the local varieties and commercial varieties. In this paper, two of those okra varieties were selected to study.

Farmers growing commercial okra in open fields need to invest more heavily. In cultivating investment, applying fertilizers is a prerequisite to improving the yield and quality of numerous crops. Among macronutrients, nitrogen is an essential element enhancing vegetative growth and the yield of okra [8, 9]. Other studies reported that the absence of nitrogen or its insufficient application causes the leaves to turn yellowish, affects the plant height and reduces the number of green pods [10, 11]. Depending on the soil fertility, various rates of applied nitrogen are suggested for okra, varying from 80 to 150 kg/ha [12–14]. However, in Vietnam, it is little known about the effect of applied nitrogen on the vegetative growth and yield of green okra. This study was, therefore, conducted to evaluate the effect of nitrogen fertilizer on two okra varieties grown under Thua Thien Hue weather conditions.

2 Material and methods

An F1 variety (from Phu Nong company) and a local variety (from Quang Binh province) were used in this study. The study was conducted at the Institute of Biotechnology, Hue University, in the spring season of 2019. The experiments were conducted in a split-plot design with three replications; the variety was in the main plots, and nitrogen fertilizer, with the following rate of 60, 90, 120, and 150 kg/ha, was in the subplot. The area of a subplot is 5 m^2, and the total experiment area is 120 m^2. The distance row to row is 1 m and plant to plant 0.4 m. The plant density is 31,250 plants/ha. Seeds were imbibed in water until germination. The germinating seeds were sown in the open field.

Fertilizing. Basal fertilizers contain 3 tons of cow manure, 100 kg of lime, and 30 kg of superphosphate for 1 ha. The fertilizer application was conducted three times with the same amount of nitrogen and KCl on the 10th, 25th, and 40th day after planting. The fertilizer was spread around the plant root.

Plant care. The plants were watered every three days. Young branches were trimmed starting from the 6th node. Digging soil and weeding were performed upon fertilizing.

Data collection and analysis

The time from sowing to the moment when 50% of the plants have first flowering, first fruiting and first harvesting was recorded. The plant height, leaf number per plant, and stock diameter

were recorded every seven days after sowing. The plant height is the distance from the ground to the top. The length and diameter of fruit were recorded from ten fruits per replicate. Yield components include

(i) Average number of fruit per plant;

(ii) Average fruit weight;

(iii) Theoretical yield (ton/ha) = (average number of fruit per plant × average fruit weight per plant × plant density/ha);

(iv) Actual yield (ton/ha) = (yield of a subplot × 10000 m^2)/sub-plot area.

The number of green worms (*Diaphania indica*) and diamondback moths (*Plutella xylostella*) per 1 m^2 was counted.

Weather conditions during spring 2019 in Thua Thien Hue

The climate data are presented in Table 1. The average air temperature was 20.4 °C in January and 30 °C in April. The rainfall was highest in January (215 mm) and lowest in April (9.2 mm). The relative humidity decreased gradually from January (94%) to April (76.1%), while evaporation increased from 78.3 to 113.6 mm. The sunny time was lowest in January (282 hours) and similar in the other months (320 hours). Okra requires a warm temperature ranging from 20 to 30 °C; thus, it is suitable to grow okra during the Winter-Spring season in Thua Thien Hue [15].

Table 1. Meteorology data in the spring season, 2019

Factor		January	February	March	April
Temperature (°C)	Maximum	23.7	350	360	41
	Minimum	15.2	170	240	220
	Average	20.4	25.6	26.7	30
Rainfall (mm)	Average	215	11.2	63.1	9.2
Humidity (%)	Average	94	81.2	78.6	76.1
Evaporate (mm)	Average	78.3	81.3	94.7	113.6
Sunny time (hour)	Average	282	318	321	323

Source: Thua Thien Hue Hydrometeorological Forecast Center

3 Results and discussion

3.1 Effect of nitrogen on growth ability of two okra varieties

The influence of nitrogen rate on the growing period is shown in Table 2. Both experimental varieties show similar times for first flowering and first fruiting for every nitrogen rate. First harvesting was recorded earliest with the F1 variety (34 days) and latest with the local variety (38 days) at the nitrogen rate of 60 kg/ha. However, most okra plants showed first harvesting after 37-day planting.

The effect of nitrogen rate on the plant height of okra is presented on Fig. 1. On the 7th and the 17th day after planting, the plant height was not affected by nitrogen application for both varieties. Only on the 37th day, the local variety produced the highest plant at a rate of 150 kg/ha (40.3 cm) and the lowest at 60 kg/ha (33.4 cm). Unlike the local variety, the F1 produced different plant heights on the 27th and the 37th day. The nitrogen rate at 150 kg/ha provided higher plants than at 90 and 60 kg/ha by about 6 cm.

Table 2. Effect of nitrogen to the growth time of okra varieties

Variety	Nitrogen (kg/ha)	Time (day)		
		Flowering	Fruiting	Harvesting
Local	60	30	33	38
	90	31	33	37
	120	30	32	37
	150	30	33	37
F1	60	32	33	34
	90	30	32	37
	120	31	34	37
	150	31	33	37

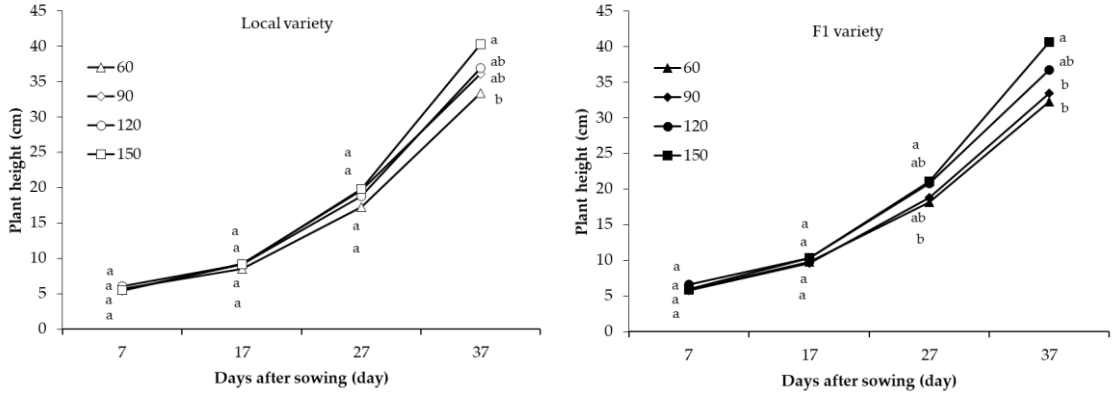

Fig. 1. Effect of nitrogen to the plant height of two okra varieties (probability $p \leq 0.05$)

The stock diameter was not affected by the nitrogen rate from 7 to 27 days of planting (Table 3). The local variety was influenced by nitrogen fertilizer from the 27th day after planting and reached the highest value of 0.84 cm (27 days) and 1.47 cm (37 days) at the 150 kg/ha nitrogen rate. However, the F1 variety exhibited different stock diameters only on the 37th day after planting, with a value of 1.69 cm at 150 kg/ha nitrogen and 1.4 cm at 60 kg/ha nitrogen. In another study, the stock diameter of the okra grown in Can Tho was smaller, and it was not affected by the amounts of nitrogen fertilizer [16].

Table 3. Effect of nitrogen to the stock diameter of two okra varieties

Variety	Nitrogen (kg/ha)	Stock diameter (cm)			
		7 days	17 days	27 days	37 days
Local	60	0.103^{a}	0.334^{a}	0.733^{c}	1.180^{b}
	90	0.117^{a}	0.371^{a}	0.817^{ab}	1.380^{ab}
	120	0.114^{a}	0.345^{a}	0.797^{b}	1.300^{ab}
	150	0.115^{a}	0.380^{a}	0.840^{a}	1.468^{a}
F1	60	0.108^{a}	0.350^{a}	0.847^{a}	1.400^{b}
	90	0.108^{a}	0.344^{a}	0.851^{a}	1.437^{ab}
	120	0.109^{a}	0.387^{a}	0.903^{a}	1.620^{ab}
	150	0.109^{a}	0.424^{a}	0.997^{a}	1.690^{a}
Nitrogen rate		ns	ns	ns	*
Variety		ns	ns	**	**
Nitrogen rate × Variety		ns	ns	ns	ns

Notes: Different letters indicate significant differences among nitrogen rates in each variety at $p \leq 0.05$. ns, *, ** indicate non-significant difference, significant different at $p \leq 0.05$ and 0.01.

The influence of nitrogen application on the leaf number of okra is shown in Fig. 2. The local variety exhibited the influence of nitrogen on the 27th day and afterwards, with the highest leaf number at 15.88 for the 150 kg N/ha rate. Meanwhile, the F1 variety produced plants with different numbers of leaves only on the 37th day after sowing, but the difference was statistically insignificant. The highest leaf number was around 20 for the 150 kg N/ha rate and the lowest at just under 15 for the 60 kg N/ha rate. Therefore, nitrogen application has a significant effect on the flowering stage of okra.

3.2 Effect of nitrogen on yield components and pest of two okra varieties

The okra varieties and nitrogen rates significantly affected fruit diameter, but their interaction was insignificant (Table 4). The difference in fruit diameter between the two varieties could be due to different genotypes. As for the nitrogen rate, the fruit diameter of the local variety was the largest at 1.76 cm when the plants were applied with 150 kg N/ha, and it was different from the others. Meanwhile, the F1 variety did not exhibit different fruit diameters with nitrogen treatments and reached its highest value at 1.87 cm. On the opposite side, the fruit length of the local variety did not differ among nitrogen treatments, but that of the F1 variety was the lowest at 60 kg/ha nitrogen (12.96 cm) and highest at 150 kg/ha nitrogen (13.56 cm).

The relationship between the independent variables (nitrogen rate and variety) and okra yield's component is shown in Table 5. The ANOVA results indicate that a significant influence was observed on fruit weight, number of fruit per plant, theoretical yield, and actual yield; however, there was no interaction between the variables. The okra fruit weight of the local variety ranged from 10.56 g (60 kg N/ha) to 12.55 g (150 kg N/ha), which is much lower than that of many

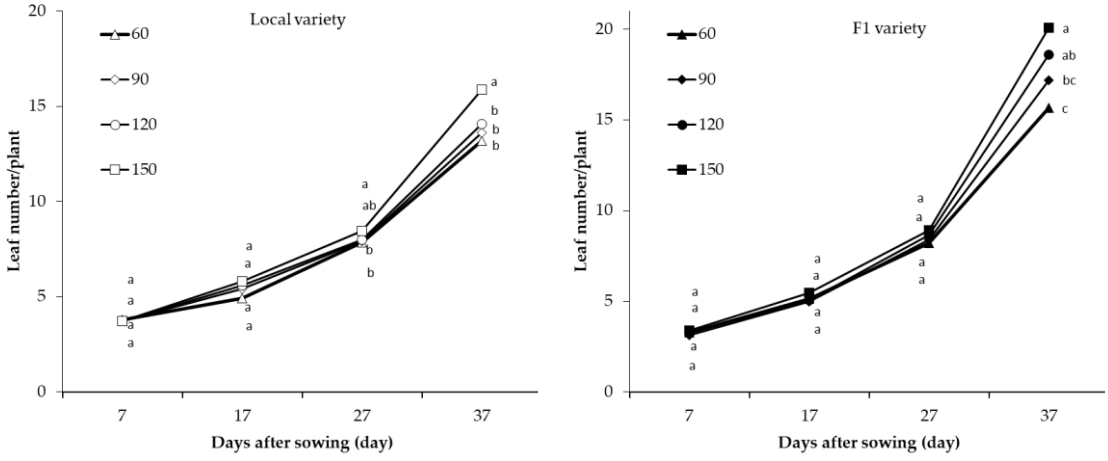

Fig. 2. Effect of nitrogen to number of leaves per plant of two okra varieties (probability $p \leq 0.05$)

varieties cultivated in Bangladesh [17]. However, the F1 variety produced a higher fruit weight than the local variety, ranging from 19.03 g (60 kg N/ha) to 21.83 g (150 kg N /ha). A higher nitrogen rate increased the average fruit weight of the local variety and the number of fruit per plant of the F1 variety. The treatment of 150 kg N/ha produced the highest yield, and it was significantly different from that of 60–90 kg N/ha treatments for both varieties. The higher growth of fruit size and the bigger number of fruit per plant due to the high amount of fertilizer application was also found in Red Burgundy okra grown in Can Tho province [16]. This indicates that a higher amount of nitrogen fertilizer produces a higher okra yield. In our study, the F1 variety provided a higher yield than the local variety (4.6 tons in theoretical yield and 3.2 tons in actual yield). Previous reports indicated that the fruit weight and the number of fruit per plant varied significantly among okra genotypes, while these traits are yield components [18, 19]. Therefore, there is a significant difference in yield between the local and F1 varieties.

In this study, the nitrogen rates of 120 and 150 kg/ha show insignificant effects on plant height, number of leaves, stock diameter, fruit diameter and length, number of fruit per plant, average fruit weight, and yield of okra. It is thought these rates are critical to apply to okra production. The yield of the vegetables grown in Thua Thien Hue could be reduced by applying a nitrogen rate of over 150 kg/ha [20].

Table 4. Effect of nitrogen to fruit diameter and length of two okra varieties

Variety	Nitrogen (kg/ha)	Diameter (cm)	Length (cm)
Local	60	1.69^{c}	11.07^{a}
	90	1.71^{bc}	10.89^{a}
	120	1.73^{b}	11.66^{a}
	150	1.76^{a}	11.89^{a}
F1	60	1.85^{a}	12.96^{b}
	90	1.83^{a}	13.09^{ab}
	120	1.83^{a}	13.29^{ab}
	150	1.87^{a}	13.56^{a}
Nitrogen rate		**	ns
Variety		**	**
Nitrogen rate × Variety		ns	ns

Notes: Different letters indicate significant differences among nitrogen rates in each variety at $p \leq 0.05$. ns, *, ** indicate non-significant difference, significant different at $p \leq 0.05$ and 0.01.

Table 5. Effect of Nitrogen on yield of two okra varieties

Variety	Nitrogen (kg/ha)	Number of fruit/plant	Average fruit weight (g)	Yield (tons/ha)	
				Theory	Actual
Local	60	9.07^{a}	10.56^{b}	2.99^{b}	2.09^{b}
	90	10.07^{a}	10.87^{b}	3.42^{b}	2.40^{b}
	120	10.53^{a}	11.83^{a}	3.89^{ab}	2.73^{ab}
	150	12.00^{a}	12.55^{a}	4.70^{a}	3.28^{a}
F1	60	10.60^{b}	19.03^{a}	6.30^{b}	4.44^{b}
	90	11.46^{b}	19.49^{a}	6.98^{b}	4.92^{b}
	120	11.87^{ab}	20.03^{a}	7.43^{ab}	5.21^{ab}
	150	13.53^{a}	21.83^{a}	9.23^{a}	6.49^{a}
Nitrogen rate		*	*	**	**
Variety		*	**	**	**
Nitrogen rate × Variety		ns	ns	ns	ns

Notes: Different letters indicate significant differences among nitrogen rates in each variety at $p \leq 0.05$. ns, *, ** indicate non-significant difference, significant different at $p \leq 0.05$ and 0.01.

Regarding pest control, the diamondback moth and green worm were observed to harm okra (Table 6).

Table 6. Effect of nitrogen to the number of diamondback moths and green worms

Variety	Nitrogen (kg/ha)	Diamondback moth (individual/m^2)	Green worm (individual/m^2)
Local	60	5.2^{a}	3.7^{ab}
	90	7.9^{a}	3.1^{b}
	120	7.5^{a}	3.6^{ab}
	150	8.8^{a}	5.7^{a}
F1	60	11.1^{a}	4.8^{a}
	90	10.8^{a}	4.7^{a}
	120	13.0^{a}	5.2^{a}
	150	16.9^{a}	7.9^{a}
Nitrogen rate		ns	*
Variety		**	*
Nitrogen rate × Variety		ns	ns

Notes: Different letters indicate significant differences among nitrogen rates in each variety at $p \leq 0.05$. ns, *, ** indicate non-significant difference, significant different at $p \leq 0.05$ and 0.01.

With the local variety, the number of green worms per metre squared was the highest at the 150 kg/ha nitrogen and lowest at 60 kg/ha nitrogen rates. Meanwhile, the number of diamondback moths was not different among the treatments and ranged from 5.2 to 8.8 individuals. With the F1 variety, the number of detected insects was similar among the nitrogen treatments. Compared with the local variety, the F1 plants exhibited more individual insects per metre squared. These results show that the F1 okra had more leaves and a larger stock diameter than the local variety. It is thought that more individuals of the diamondback moths and the green worms were found in the F1 variety because of their bigger plants.

4 Conclusion

We can conclude that nitrogen at 60, 90, 120 and 150 kg/ha significantly affects the growth and yield of two okra varieties in this study. The rate of 150 kg nitrogen/ha is recommended to apply to okra grown in the Winter-Spring season in Thua Thien Hue.

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