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EFFECT OF PLANT DENSITY AND FOLIAR FERTILIZER SPRAY ON GROWTH AND YIELD OF NETTED MELON (*Cucumis melo* L.) 'Inthanon RZ'

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Abstract. The cultivation of netted melon is becoming popular in vegetable farms in Vietnam. The netted melon cultivar 'Inthanon RZ' was evaluated for its growth ability, yield, fruit quality, and economic efficiency when treated with densities of 38,000 and 33,000 plants/ha and four foliar fertilizer sprays: Biotic foliar AMINO ACID 1000, NPK NUTRI-GOLD 29-10-10 + 3 MgO + TE, NPK HAI-CHYODA 14-17-12 + 12 S, and NPK DAU TRAU 30-10-5 + TE. The experiment was conducted in a plastic house at the Biotechnology Institute of Hue University from January to April 2019. The experiment area was 72 m^2. The results indicate that plants have a similar growth time under the cultivation conditions. The plants grown with the density of 38,000 plants/ha exhibit a higher leaf area index. The actual yield ranges from 34.00 tons/ha (AMINO ACID 1000; 33,000 plants/ha) to 46.22 tons/ha (NPK HAI-CHYODA 14-17-12 + 12 S; 38,000 plants/ha). Applying NPK HAI-CHYODA 14-17-12 + 12S or NPK DAU TRAU results in the Brix grade higher than 12.0 for both plant densities. Powdery mildew is the most frequently observed in the treatments with NPK DAU TRAU. The yield and profit obtained from trading the melon are highest for the density of 38,000 plants/ha with fertilizer NPK HAI-CHYODA 14-17-12 + 12S.

Keywords*:* biotic foliar, Brix, economic efficiency, Inthanon RZ, netted melon

1 Introduction

Netted melon (*Cucumis melo* L.) is a common dessert fruit and grown widely in the world. It is a favoured fruit because of its delicious flavour, sweet taste, and high nutritious content. One gram of melon contains 20.4 μg of beta-carotene (a precursor of vitamin A), about 100 times more than the apple, 20 times more than the orange, and 10 times more than the banana [1]. In local fruit markets, netted melon is a high-value fruit; thus, growers can get a high income from producing this kind of melon. However, netted melon has been introduced as a new vegetable crop to Vietnam only recently, and it should be grown under protected conditions such as plastic houses. There is little information on the cultivation technique of this new crop in the literature.

In Thua Thien Hue province, various kinds of vegetables and cucurbit plants easily adapt to this area's hot, humid climate. However, high-quality netted melon production is limited; thus, many commercial high-quality melons in the markets are supplied from other provinces. As a result, the melon quality is diminished due to the long delivery time and storage conditions [2].

To introduce netted melon to the local crop structure of Thua Thien Hue, we investigate and

establish the cultivation technique for this fruit to grow under the local climate. Plant density contributes profoundly to absorbing sunlight and weed competitiveness of agronomical crops, affecting the final yield [3]. For instance, 11,111 plants/ha is a recommended density in the spring–summer season in Thai Nguyen province [4], or 25,000–27,000 plants/ha in the dry season and 22,000–25,000 plants/ha in the rainy season in the south of Vietnam [5]. Besides, intensive application of root fertilizer improves the quality of soil and the bacteria system. The foliar spray is also used to reduce root-knot nematode in melon [6]. A foliar spray containing potassium increases the contents of soluble solids, ascorbic acid, and beta-carotene of muskmelon [7].

In a previous study, we examined the growth ability under weather conditions in the Spring–Summer season in Thua Thien Hue for several F1 hybrids of melon [2]. In this study, we investigate the effects of plant density and foliar fertilizer spray on the growth and yield of netted melon.

2 Materials and methods

2.1 Experimental design

The netted melon cultivar used in this study is 'Inthanon RZ'. We study two densities: 38,000 and 33,000 plants/ha. The commercial foliar fertilizer sprays include:

(i) Biotic foliar AMINO ACID 1000 (Nitrogen, Arginine, Total L-form Amino Acid, Threonine, Glycine, Valine, Glutamic acid, Phenylalanine, Aspartic acid, Isoleucine, Alanine, Histidine, Proline, Methionine, and Leucine); (ii) NPK NUTRI-GOLD 29-10-10 + 3 MgO + TE (29% N, 10% P2O5, 10% K2O, 3% MgO, and TE: B, Cu, Zn) originated from Germany; (iii) NPK HAI-CHYODA 14-17-12 + 12S (14% N, 17% P2O5, 12% K2O and 12% S) originated from Japan; (iv) NPK DAU TRAU 30-10-5 + TE (30% N, 10% P2O5, 5% K2O, 0.05% CaO, 0.05% MgO and TE: B, Cu, Zn).

The experiments were conducted in a three-replicate split-plot design of 2 × 4 treatments, with plant density as the main plot and foliar fertilizer spray as the sub-plot. The area of a sub-plot is 3 m^2, and the total experiment area is 72 m^2. Foliar fertilizers were applied weekly, starting at transplantation and finishing three weeks before harvesting.

2.2 Cultivation methods

The netted melon seeds were sown on a plastic tray containing one part of soil and one part of rice husk ash. The medium was watered and kept wet every day. The seedlings were raised until having 4–6 true leaves for transplantation. Netted melon was grown in well-drained soil with pH 6.5–7.0. The height of the soil bed is 20 cm, and the width is 100 cm. The soil bed was covered with plastic mulch to prevent weeds. The basal soil application is as follows: 20 tons/ha manure, 80 kg/ha N, 90 kg/ha P_2O_5, 150 kg/ha K_2O, and 400 kg/ha lime. Lateral branches and flowers from the 1st to 10th node were pinched out. Female flowers from the 10th to 13th nodes were hand-pollinated in the early morning. After fruiting for a week, some fruits were removed to leave only the best one on the plant.

2.3 Data collection and analysis

Days from sowing to the moment when 50% of the plants have the first tendril, first branching, and first female flowering, and last harvesting were recorded. The plant height is the distance from the ground to the top when the plant has 25 leaves. The average growth parameters of five plants per replication include:

(i) Number of leaves at every seven days until the 25th leaf; (ii) Leaf area (weight of 1-dm2

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the 10th leaf/weight of leaf × total number of leaves); (iii) Leaf index (leaf area per 1 m2 of soil); (iv) Number of female flowers per plant after every three days.

Yield components include:

(i) The average number of fruit per plant; (ii) Average fruit weight; (iii) Theoretical yield (average number of fruit per plant × average fruit weight × plant density); (iv) Actual yield (yield of a sub-plot/sub-plot area).

Fruit quality includes Brix grade and fruit pulp thickness. The percentages of powdery mildew and green worm were investigated in five plants per replication. Economic efficiency is based on the profit from assumed trading of all harvested netted melons. Profit is measured as Income (total number of harvested fruits × average fruit weight × 80,000 VND) minus Outcome (value of foliar fertilizer spray + value of labour). Recorded data were expressed as a mean value and compared according to the significant differences.

2.4 Weather conditions during Spring season 2019 in Thua Thien Hue

Melons prefer sufficient sunshine and a warm climate. According to Table 1, the weather conditions in the spring season in Thua Thien Hue are suitable for growing melons. The average temperature is from 20.4 °C (January) to 30.0 °C (April). The minimum and maximum temperatures increase from January to April. Total rainfall is highest in January (215 mm) and drastically decreases in February–April (9.2–11.2 mm). Sunshine time is from 282 hours (February) to 323 hours (April).

3 Results and discussion

3.1 Growth ability

Growth parameters of the netted melon differ significantly in the treatments (Table 2). The time from sowing to the first tendril ranges from 27.0 days (NPK DAU TRAU, 33,000 plants/ha) to 19.0 days (AMINO ACID 1000, 38,000 plants/ha). The time from sowing to first branching with NPK HAI-CHYODA spray and 38,000 plants/ha density is shorter than that with the same spray and 33,000 plants/ha density and shorter than that of other treatments except for NPK DAU TRAU and 38,000 plants/ha density. Foliar fertilizer sprays affect the first female flowering. The flowering time with NPK HAI-CHYODA and NPK DAU TRAU is shorter than that with AMINO ACID 1000 and similar to that with NPK NUTRI-GOLD and both plant densities. Harvesting time is longest with sprays AMINO ACID 1000 (75.0 days) and NPK NUTRI-GOLD (74.6 days) and 38,000 plants/ha density and longer than that of other sprays and 33,000 plants/ha density. Some melon varieties cultivated widely in Vietnam have harvesting time between 70 and 75 days [2].

Table 1. Weather conditions during Spring season 2019 in Thua Thien Hue

Factor		January	February	March	April
Temperature (°C)	Maximum	23.7	35	36	41
	Minimum	15.2	17	24	22
	Mean	20.4	25.6	26.68	30
Rainfall (mm)	Mean	215	11.2	63.1	9.2
Shining time (hour)	Mean	282	318	321	323

Table 2. Effect of different plant densities and foliar treatments on time from sowing to important stages of netted melon 'Inthanon RZ'

Treatment		First tendril (day)	First branching (day)	First female flowering (day)	Harvesting (day)
38,000 plants/ha	AMINO ACID 1000	29.0$^{a\ y}$	28.0^{abc}	34.0^{ab}	75.0^{a}
	NPK NUTRI-GOLD	28.3^{ab}	28.0^{abc}	32.6^{bcd}	74.6^{a}
	NPK HAI-CHYODA	27.3^{b}	26.0^{d}	31.3^{d}	72.3^{bc}
	NPK DAU TRAU	28.3^{ab}	27.3^{cd}	31.3^{d}	72.0^{c}
33,000 plants/ha	AMINO ACID 1000	28.3^{ab}	29.3^{a}	34.3^{a}	73.3^{b}
	NPK NUTRI-GOLD	28.0^{ab}	27.6^{bc}	33.0^{abc}	73.0^{bc}
	NPK HAI-CHYODA	27.6^{ab}	29.0^{ab}	31.6^{cd}	72.3^{bc}
	NPK DAU TRAU	27.0^{b}	28.6^{abc}	31.6^{cd}	72.0^{c}
$LSD_{0.05}$		0.6	0.65	0.44	0.47

Note: ^{y} Different letters in each column indicate significant differences among varieties at $p \leq 0.05$.

The plant height of netted melon 'Inthanon RZ' increases rapidly from 14 days after sowing (Fig. 1). The plant density and foliar fertilizer sprays do not affect the plant height throughout the growth stages. With both plant densities, the number of female flowers is similar until 33 days after sowing (Fig. 2). At 36 days after sowing, the number of female flowers is largest (3.2) with foliar spray HAI-CHYODA and 38,000 plants/ha density and similar among the spray treatments and 33,000 plants/ha density. At 39 days after sowing, the number of female flowers with foliar spray HAI-CHYODA is larger than that with foliar fertilizer sprays Amino acid and Nutri Gold and 38,000 plants/ha density. In contrast, there is no difference with 33,000 plants/ha density. The total number of female flowers ranges from 10.1 (NPK NUTRI-GOLD and 33,000 plants/ha density) to 12.8 (NPK NUTRI-GOLD and 38,000 plants/ha density) (data not shown). The number of female flowers is smaller than that of netted melon 'Inthanon RZ' grown in the Winter–Spring season 2018 in Thua Thien Hue [2].

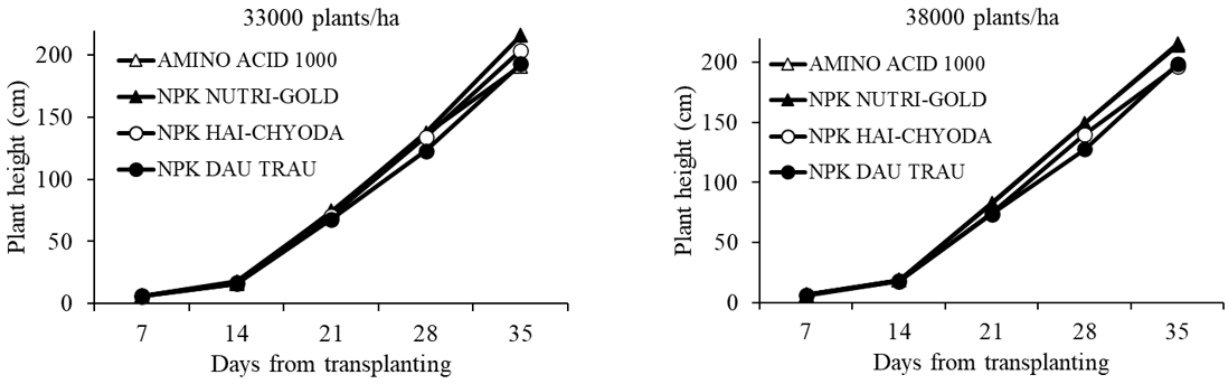

Fig. 1. Effect of plant density and foliar fertilizer sprays on plant height of netted melon 'Inthanon RZ'

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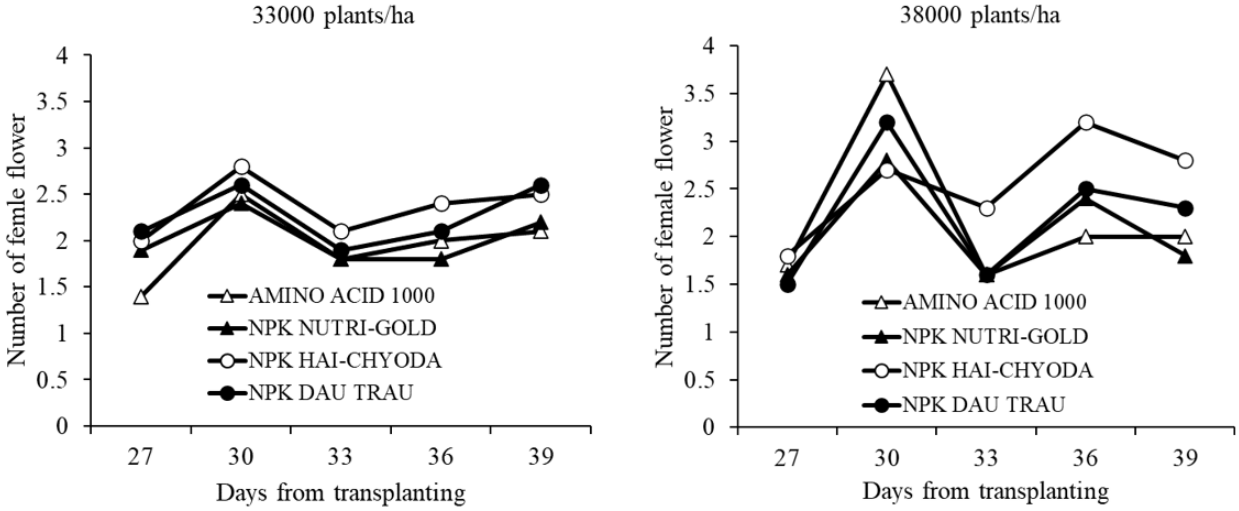

Fig. 2. Effect of plant density and foliar fertilizer sprays on plant height of netted melon 'Inthanon RZ'

Table 3 shows the leaf traits. The number of leaves does not change with either plant density or foliar fertilizer sprays. The leaf area of plants with sprays NPK HAI-CHYODA and NPK DAU TRAU and 33,000 plants/ha density is larger than that of plants with sprays NPK HAI-CHYODA, NPK NUTRI-GOLD, and AMINO ACID 1000 and 38,000 plants/ha density. The leaf area index of all plants with 38,000 plants/ha density is higher than that of plants with 33,000 plants/ha density. With the density of 38,000 plants/ha, the leaf area index of NPK DAU TRAU is higher than that of NPK NUTRI-GOLD and AMINO ACID 1000. With the density of 33,000 plants/ha, the leaf area index is not affected by foliar fertilizer sprays.

Table 3. Effect of different plant densities and foliar treatments on leaf development of netted melon 'Inthanon RZ'

Treatment		Number of leaves	Leaf area (m^2/plant)	Leaf area index
38,000 plants/ha	AMINO ACID 1000	27.1$^{a\,y}$	0.84^{cd}	3.36^{bc}
	NPK NUTRI-GOLD	27.3^{a}	0.81^{d}	3.25^{c}
	NPK HAI-CHYODA	26.4^{a}	0.87^{bc}	3.48^{ab}
	NPK DAU TRAU	27.3^{a}	0.89^{ab}	3.56^{a}
33,000 plants/ha	AMINO ACID 1000	25.6^{a}	0.89^{ab}	2.69^{d}
	NPK NUTRI-GOLD	27.6^{a}	0.90^{ab}	2.71^{d}
	NPK HAI-CHYODA	26.6^{a}	0.92^{a}	2.75^{d}
	NPK DAU TRAU	25.8^{a}	0.92^{a}	2.76^{d}
$LSD_{0.05}$		1.19	0.02	0.07

Note: ^{y} Different letters in each column indicate significant differences among varieties at $p \leq 0.05$.

3.2 Yield components

Although the average fruit weight is similar (1.06–1.39 kg) among treatments, the theoretical and

actual yields are different (Table 4). Treatments with NPK HAI-CHYODA and both plant densities provide the highest theoretical yield (51.41 tons/ha) with 38,000 plants/ha density and 53.71 tons/ha with 33,000 plants/ha density. The treatments with AMINO ACID 1000 produce the lowest theoretical yield (38.28 tons/ha) with 38,000 plants/ha density and 37.62 tons/ha with 33,000 plants/ha density. The actual yield is highest with NPK HAI-CHYODA and 38,000 plants/ha density (46.22 tons/ha) and 33,000 plants/ha density (46.11 tons/ha). Other sprays produce similar actual yields, except for AMINO ACID 1000 and 33,000 plants/ha density (34.00 tons/ha, the lowest) and lower than that with NPK HAI-CHYODA and 38,000 plants/ha density. At the plant density of 33,000 plants/ha, the yield of 'Inthanon RZ' grown with foliar fertilizer sprays of this study is 1.6–2.2 times higher than that of the traditional variety 'Kim Co Nuong' grown without foliar fertilizer [8]. This difference could be due to the fruit traits, fertilizer application, and climate conditions.

3.3 Fruit quality

Factors such as genotypes, agro-environmental conditions, and fertilization can improve the fruit quality of melons [8]. In this study, plant density and foliar fertilizer do not influence the pulp thickness of netted melon 'Inthanon RZ'. The thickness is similar among treatments and ranges from 3.53 to 4.48 cm (Table 5). However, the Brix grade is different, ranging from 10.04° to 13.59°. Some muskmelon genotypes grown in India also have the Brix grade from 11.60° to 14.04° [10]. The Brix grade of the melon treated with NPK HAI-CHYODA and NPK DAU TRAU and both densities exhibits similar values (12.05–13.59°). The Brix grade of AMINO ACID 1000 treated melon is lowest (10.04–10.48°) and is similar to that of NPK NUTRI-GOLD treated melon with both plant densities. Potassium in the foliar fertilizer of the NPK type in this study might affect the Brix grade of melon pulp. In other reports, potassium affects the soluble-solid content of melon fruits significantly [7, 11].

Table 4. Effect of different plant densities and foliar treatments on harvesting traits of netted melon 'Inthanon RZ'

Treatment		Average fruit weight (kg/fruit)	Theory yield (tons/ha)	Actual yield (tons/ha)
38,000 plants/ha	AMINO ACID 1000	1.17$^{a\,y}$	38.28^{bcd}	37.78^{ab}
	NPK NUTRI-GOLD	1.27^{a}	48.60^{ab}	43.56^{ab}
	NPK HAI-CHYODA	1.39^{a}	51.41^{a}	46.22^{a}
	NPK DAU TRAU	1.36^{a}	49.15^{ab}	45.33^{ab}
33,000 plants/ha	AMINO ACID 1000	1.02^{a}	37.62^{cd}	34.00^{b}
	NPK NUTRI-GOLD	1.06^{a}	40.92^{abc}	36.44^{ab}
	NPK HAI-CHYODA	1.17^{a}	53.71^{a}	46.11^{ab}
	NPK DAU TRAU	1.16^{a}	43.07^{abc}	38.67^{ab}
$LSD_{0.05}$		0.19	6.23	5.27

Note: ^{y} Different letters in each column indicate significant differences among varieties at $p \leq 0.05$.

Table 5. Effect of different plant densities and foliar treatments on fruit flesh thickness and brix of netted melon 'Inthanon RZ'

Treatment		Fruit flesh thickness (cm)	Brix grade (°)
38,000 plants/ha	AMINO ACID 1000	4.48$^{a\,y}$	10.04^{d}
	NPK NUTRI-GOLD	4.12^{a}	10.23^{cd}
	NPK HAI-CHYODA	3.86^{a}	13.59^{a}
	NPK DAU TRAU	4.30^{a}	13.29^{ab}

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Treatment		Fruit flesh thickness (cm)	Brix grade (°)
33,000 plants/ha	AMINO ACID 1000	3.62[a]	10.48[cd]
	NPK NUTRI-GOLD	3.72[a]	11.55[bcd]
	NPK HAI-CHYODA	3.97[a]	12.05[abc]
	NPK DAU TRAU	3.53[a]	12.64[ab]
$LSD_{0.05}$		0.19	0.73

Note: [y] Different letters in each column indicate significant differences among varieties at $p \leq 0.05$.

3.4 Insects and diseases

Powdery mildew and green worms affect the growth of melon widely. According to Table 6, with both plant densities, the incidence of powdery mildew is lowest when spraying NPK HAI-CHYODA (6.67%) and highest when spraying NPK DAU TRAU (60.00%). Green worms are found more frequently when spraying AMINO ACID 1000 (8%), NPK NUTRI-GOLD (9.33%), and NPK HAI-CHYODA (6.67%).

3.5 Economic efficiency

According to Table 7, the number of fruits and the total fruit weight are higher with NPK HAI-CHYODA spray (23–24 fruits) and NPK DAU TRAU spray (18 fruits) and each plant density. Therefore, applying these two foliar fertilizers results in higher income and profit than the other sprays with each plant density. Besides, the density of 38,000 plants/ha provides a higher number of harvested fruits than the density of 33,000 plants/ha. For instance, applying NPK HAI-CHYODA spray provides 1.69 times higher profit with the density of 38,000 plants/ha than with the density of 33,000 plants/ha.

Table 6. Effects of plant density and foliar fertilizer sprays on incidence of disease and worm in netted melon 'Inthanon RZ'

Treatment		Powdery mildew (%)	Green worm (%)
38,000 plants/ha	AMINO ACID 1000	13.33	8.00
	NPK NUTRI-GOLD	20.00	9.33
	NPK HAI-CHYODA	6.67	6.67
	NPK DAU TRAU	40.00	2.67
33,000 plants/ha	AMINO ACID 1000	20.00	6.00
	NPK NUTRI-GOLD	46.67	7.00
	NPK HAI-CHYODA	13.33	6.00
	NPK DAU TRAU	60.00	4.00

Table 7. Effects of plant density and foliar fertilizer sprays on economic efficiency

Treatment		Number of harvested fruits	Total fruit weight (kg)	Outcome (VND)	Income (VND)	Profit (VND)
38,000 plants/ha	AMINO ACID 1000	20	23.4	327,000	1,872,000	1,545,000
	NPK NUTRI-GOLD	20	25.4	312,000	2,032,000	1,720,000
	NPK HAI-CHYODA	24	33.36	315,000	2,668,800	2,353,800
	NPK DAU TRAU	23	31.28	322,000	2,502,400	2,182,400

Treatment		Number of harvested fruits	Total fruit weight (kg)	Outcome (VND)	Income (VND)	Profit (VND)
33,000 plants/ha	AMINO ACID 1000	14	14.28	303,000	1,142,400	839,400
	NPK NUTRI-GOLD	15	15.9	288,000	1,272,000	984,000
	NPK HAI-CHYODA	18	21.06	291,000	1,684,800	1,393,800
	NPK DAU TRAU	18	20.88	298,000	1,670,400	1,372,400

4 Conclusion

Netted melon 'Inthanon RZ' planted in the plastic house in the Spring season has a growth time from 72.0 to 75.0 days after transplanting. Applying NPK HAI-CHYODA 14-17-12 + 12S or NPK DAU TRAU results in a higher Brix grade than 12.0 with both plant densities. The yield and the profit obtained from selling the fruit are highest when planting melon with 38,000 plants/ha density and the NPK HAI-CHYODA 14-17-12 + 12S spray. The density of 38,000 plants/ha and the foliar fertilizer spray NPK HAI-CHYODA 14-17-12 + 12S should be investigated further for other netted melon cultivars to recommend the most suitable method for growing netted melon in Thua Thien Hue.

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