Multi-objective Monitoring for the Quality Improvement of Netted Melon (*Cucumis melo* L. var. *reticulatus*) through Precise Nitrogen and Potassium Management in a Hydroponic System

Rita S.W. YAM[1]*, Yen-Tzu FAN[1], Jing-Tian LIN[2],

Chihhao FAN[1], Hsiao-Feng LO[2]

[1]Dept. Bioenvironmental Systems Engineering, National Taiwan University, Taiwan

[2]Dept. Horticulture and Landscape Architecture, National Taiwan University, Taiwan

Netted melon (*Cucumis melo* L. var. *reticulatus*)

- Commercial fruits
  - High-price, high-quality

- Not easy to grow
  - Sensitive to temperature (optimal range: 25-30˚C)
  - One-plant, one-melon
  - Vulnerable to pests and diseases

Netted melon in Japan

King of fruits

Natural climate

Spring-summer in temperate region

High-price, high-quality (appearance, fragrance, taste)

Beautiful appearance, musky fragrance, juiciness, full flavor, and smoothness

30-100 USD or more per melon (about 1.5 kg)

Harvest about **100 days**

Outdoor: harvest once a year

In greenhouse: 1-2 times a year

Netted melon in subtropical & tropical regions

Climate

- Too hot
- Natural disasters (e.g. typhoons, heavy rain events)
- Pest invasion

Cultivation in **greenhouse**

- Controlled environment → high-quality
- Avoiding pests
- Suitable temp. through year (may be harvested >2 times?)
- → **Precision agriculture for high-quality fruits**

Precision agriculture

- Management in precise growing conditions
  - e.g. water, nutrients, fertilizers
  - Well controlled systems → hazards ↓, yields ↑

- Development of **remote sensing** technology applied on **agriculture**
  - → Continuous monitoring
  - Requiring **accurate knowledge of plant growth in responses to various environmental factors**

Hydroponic systems in agriculture

Water-based cultivation

- **Faster growth of plant**: direct water and nutrient absorption
- **Enclosed system**: effectiveness of nutrient manipulation
- Reduce diseases (no pests from soil)

Do not require soil

(e.g. plant factories, green roofs)

Hydroponic systems applying in netted melon cultivation

Various fruit qualities in previous studies

Fruit weight, total soluble solids (TSS), growing days

Not consistent fruit qualities

	USA-California	Japan	Japan	Malaysia	Thailand
Melon weight (kg)	0.6-1.9	2.4	0.8-1.5	1.2	0.6-0.7
TSS (%)	9.5-10.5	14.7	10.5-16.1	13.2	12-15
cultivation periods (days)	90-150	>80	90-110	N.D.	>72
References	Rodriguez et al. 2006; Rodriguez et al. 2007	Asaduzzaman et al. 2018	Ikeda et al. 1996	Lim 1985	Wiangsamut et al. 2017

N.D.: no data

To manipulate nutrient levels → high-quality fruits

Nitrogen(N) effects on plant growth

Essential constituent of proteins

- Energy transfer compounds
- Component of chlorophyll
- → Stimulate vegetative growth and root growth

Deficiency of N → ↓ plant growth

Excessive N

- ↑ Mineral salts → dehydration
- → Leaf burning and wilting or stunting root growth

(McCauley 2010; Leghari et al. 2016)

Potassium (K) effects on fruit qualities

Transport sugar to fruits

↑ Sucrose, glucose, fructose

↑ Taste, aroma

↑ **Sweetness, overall preferences**

↑ Fruit firmness → reduce fruit cracking

Early fruit maturation → shorten growing periods

(Lin et al. 2004; Lester et al. 2010; Asao et al. 2013; Asaduzzaman et al. 2018)

Goals of our tests

High variation of plants for N & K demand during different developmental stages

To determine **precise N and K fertilization** for producing high-quality melon

To **increase economic benefits** of melons

↑ Fruit qualities (e.g. yields, sweetness, flavor)

↑ Overall preferences

↓ Fertilizer waste: most efficient fertilization

Aims

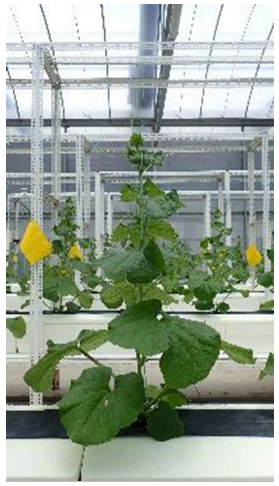
- To investigate the **optimal N and K fertilization**
  - Through adjustment hydroponic nutrient solutions (N and K contents) during different plant developmental stages
- To evaluate the effects of nutrient adjustment on:
  - **Plant development**: growth rate, stem width, and chlorophyll
  - **Fruit quality**: weight, shape, sugar contents, and flesh mass
  - **Overall preferences** based on blind test

MATERIALS & METHODS

Netted melon cultivation

In greenhouse

- Transplant on 22 days after seeding
- Experimental periods: Aug-Oct, 2018
- Controlled water temp.
- Natural light


Hydroponic systems

- Enclosed nutrient cycling

Adjusted nutrient treatments

	VG	PSF	FE
CT	100%N 100%K	100%N 100%K	100%N 100%K
II	75%N 75%K	75%N 125%K	100%N 100%K
III	75%N 75%K	75%N 125%K	75%N 125%K

*VG: vegetation growth; PSF: pollination and small fruits; FE: fruit enlarge

To avoid excessive fertilization

To evaluate efficiency of N and K fertilization

Remote sensing applied on agriculture

- **Efficient fertilization**
  - Background knowledge for growing high-quality melons
- **Real-time monitoring** in every 5 minutes
- Development of **remote sensing technology**
  - Linking to agricultural knowledge
  - Continuous monitoring to help maintaining consistent fruit qualities by automatic sensing and nutrient adjustment

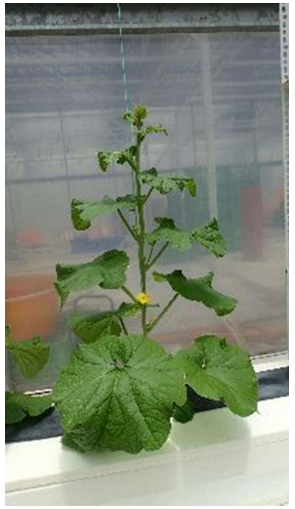
Water chemistry monitoring

- Physiochemical parameters
  - Water temp., pH, DO, ORP, EC
- Regular sampling of hydroponic nutrient solution
  - Nutrients: NH_4-N, NO_3-N, PO_4-P
  - Essential elements: K, Ca, Mg, Na



Plant growth & fruit qualities

- Growth rate, stem width, chlorophyll
- Fruit maturation time
- Fruit morphology
- Weight, shape, firmness
- Flesh characteristics
- Thickness, total soluble solids, total salt content, ascorbic acids, nitrate, essential elements



Blind tests

- Fruit aroma
- Texture
- Sweetness
- Overall preference

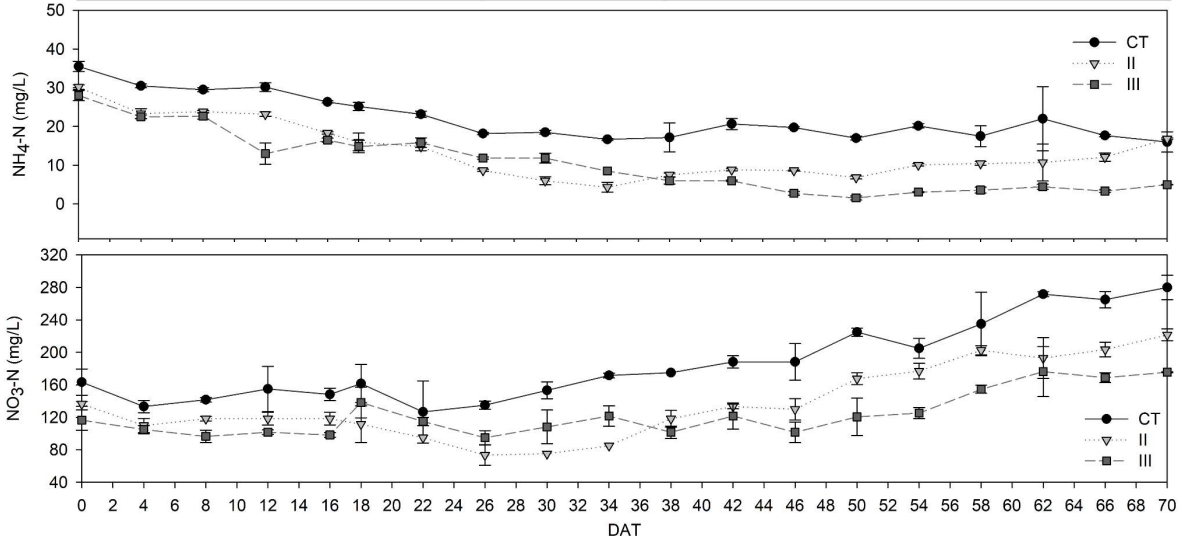
RESULTS & DISCUSSION

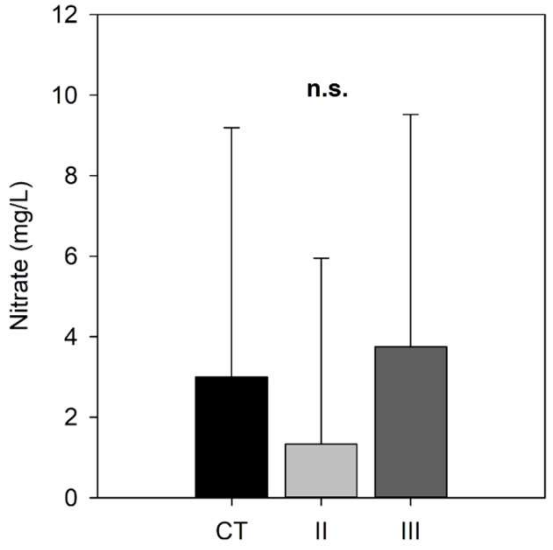
N contents in hydroponic nutrient solution and fruits

II and III: lower N concentration in water during whole planting periods

No difference of N contents in fruits among all treatments

VG	PSF	FE
CT:100% N,100% K II: 75% N, 75% K III: 75% N, 75% K	CT:100% N,100% K II: 75% N, 125% K III: 75% N, 125% K	CT:100% N,100% K II: 100% N, 100% K III: 75% N, 125% K



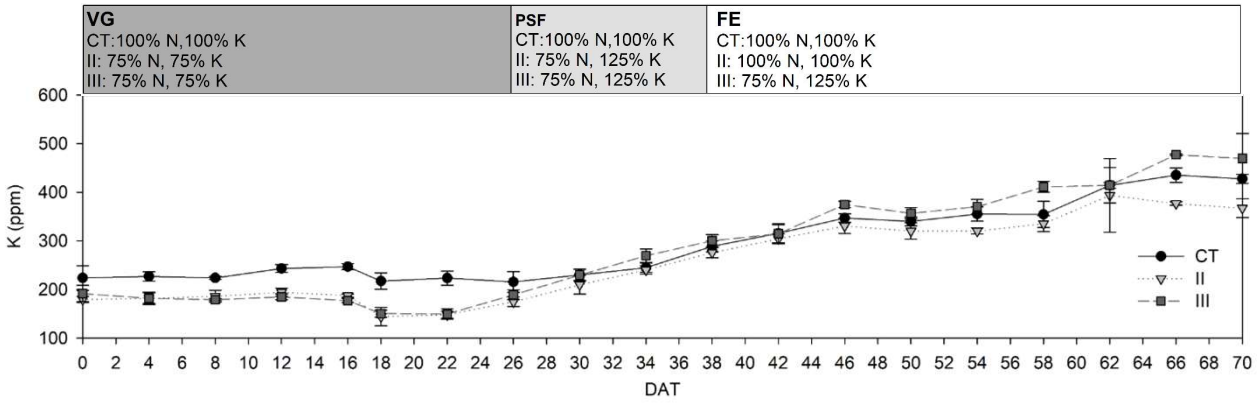


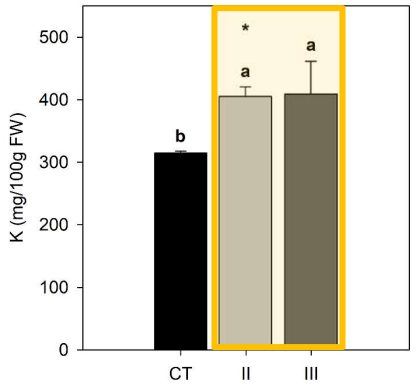
K contents in hydroponic nutrient solution and fruits

VG: low-K in both II and III

PSF: high-K in II and III

FE: II → adjusted to 100%; III → maintaining high-K



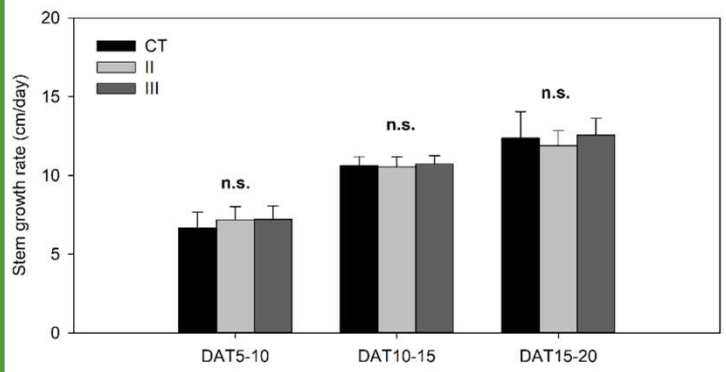


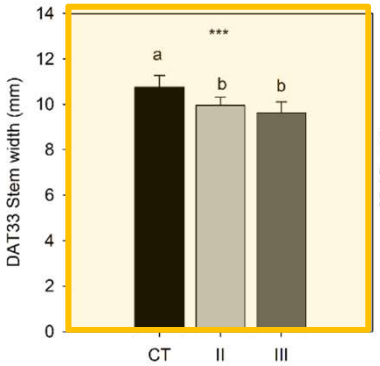
N manipulation – plant growth

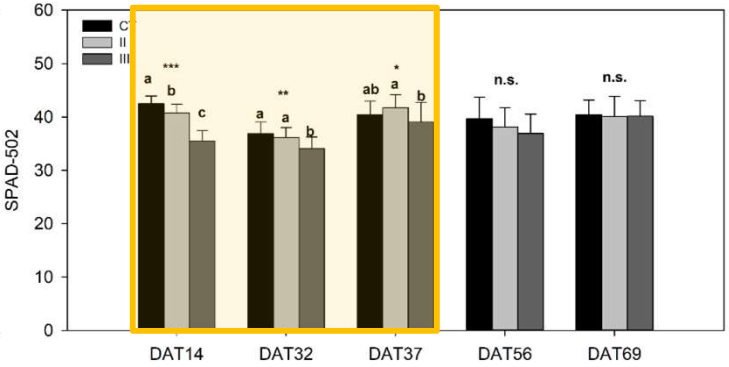
Low-N in II and III (VG and PSF)

- No negative effects on plant growth rates
- **Stems thinner** during PSF
- Reduced Chlorophyll during VG and PSF

	VG	PSF	FE
CT	100%N 100%K	100%N 100%K	100%N 100%K
II	75%N 75%K	75%N 125%K	100%N 100%K
III	75%N 75%K	75%N 125%K	75%N 125%K



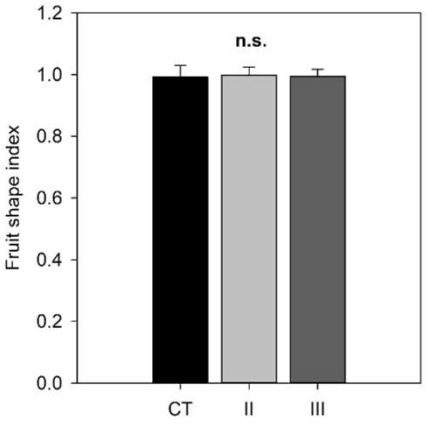


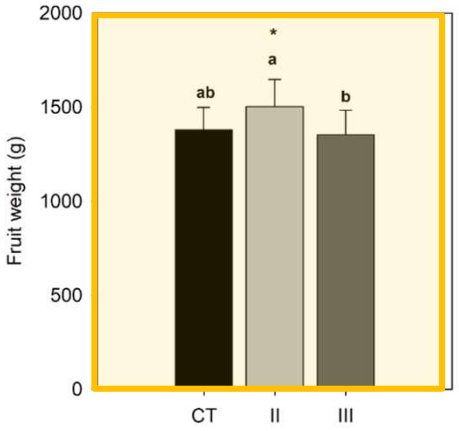


K effects on fruit qualities – shapes and yields

No difference in fruit shapes

But, **fruit weight increased for II**





	VG	PSF	FE
CT	100%N 100%K	100%N 100%K	100%N 100%K
II	75%N 75%K	75%N 125%K	100%N 100%K
III	75%N 75%K	75%N 125%K	75%N 125%K

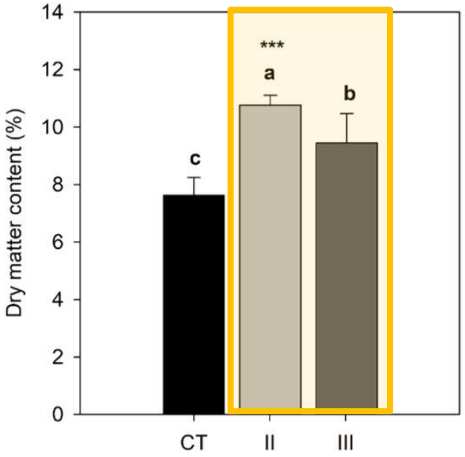
*shape index= length/width

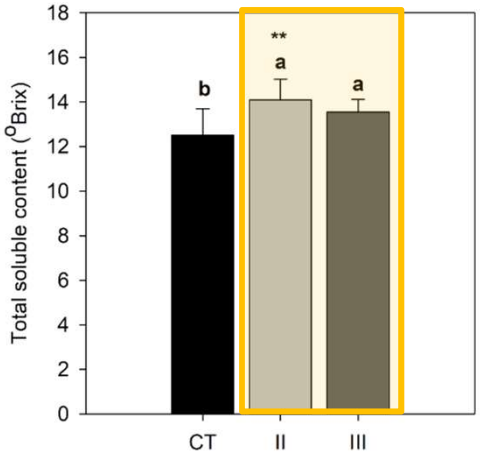
K effects on fruit qualities – flesh characteristics

↑ Fruit flesh mass

K manipulation → ↓ water content in melon, ↑ flesh thickness

↑ Sugar content





	VG	PSF	FE
CT	100%N 100%K	100%N 100%K	100%N 100%K
II	75%N 75%K	75%N 125%K	100%N 100%K
III	75%N 75%K	75%N 125%K	75%N 125%K

Manipulation of N and K

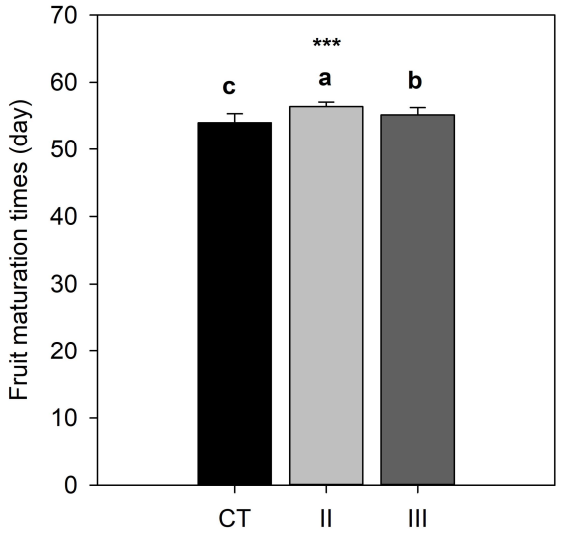
No strong effects on plant growth

↑ Fruit weight (only II)

↑ Flesh dry mass

↑ Sugar contents

No effect on fruit shapes

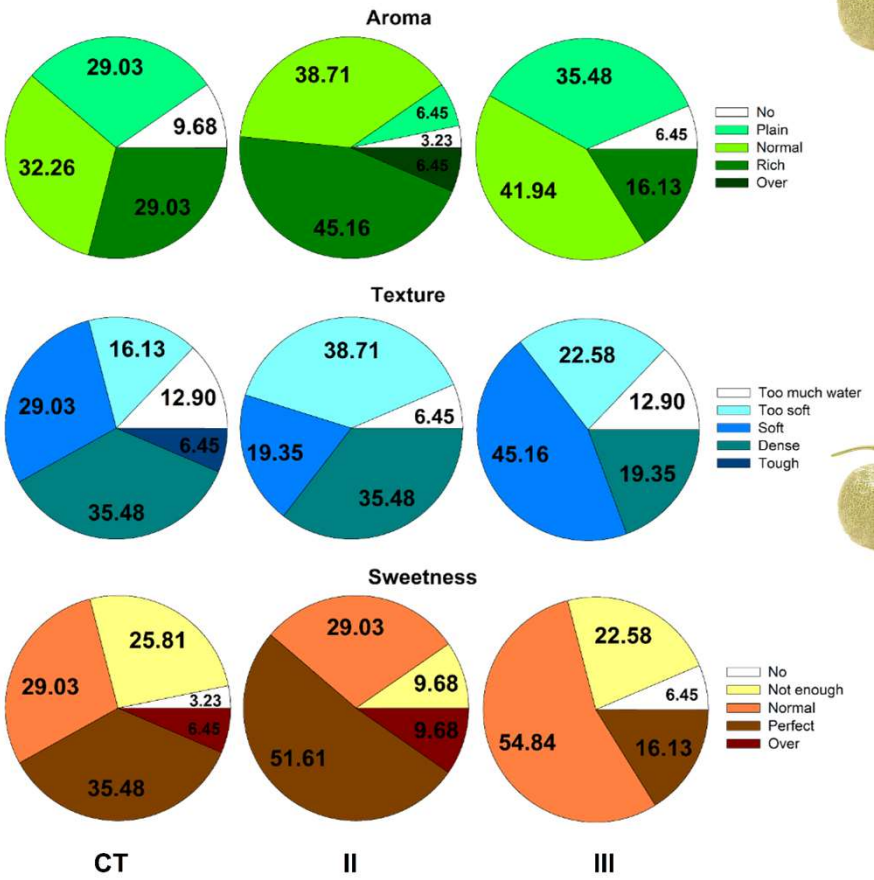


↑ Maturation time (CT: 54 days; II:56.5 days; III: 55.2 days)

N and K manipulation for treatment II & III

↑ fruit qualities, but need more days for maturation

Blind test results – aroma and taste



II:

- Stronger aroma
- Texture dense but not tough
- Perfect sweetness

III:

- Weak aroma
- Texture too soft
- Normal sweetness

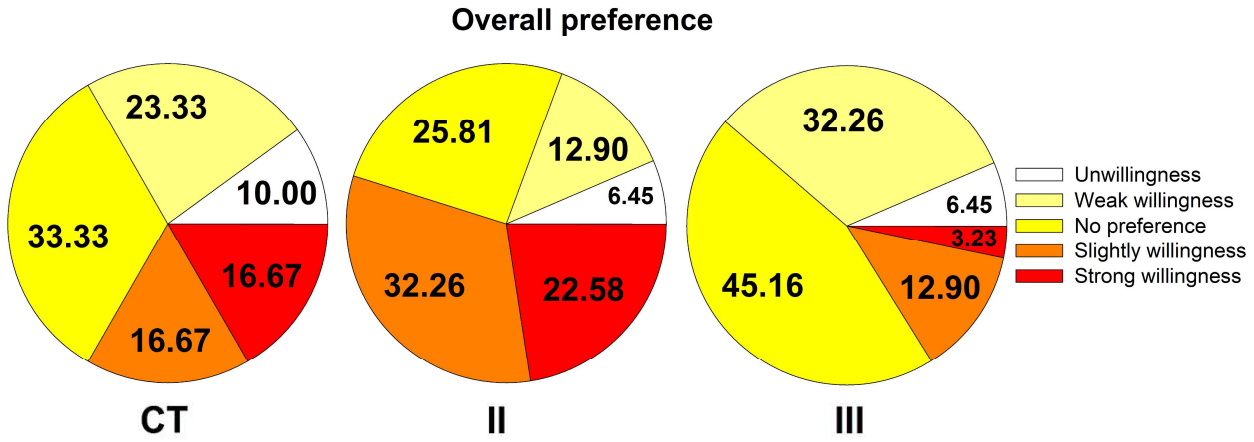
Blind test results – overall preference

II: ↑ ; III: ↓

N and K adjustment:

Excessive K with low-N at FE → **reduce overall preference**

	VG	PSF	FE
CT	100%N 100%K	100%N 100%K	100%N 100%K
II	75%N 75%K	75%N 125%K	100%N 100%K
III	75%N 75%K	75%N 125%K	75%N 125%K



Comparison with Earl's melons (*Cucumis melo* L.) in Japan

In Taiwan: **growing faster** (~ 5 days)

Fruit weight & TSS

II → **Mountain class** (grade 2 in Japan)

	Japan (temperature region)				This study (subtropical & tropical region)		
	Fuji (0.1%)	Mountain class (25%)	White class (55%)	Normal	CT	II	III
Melon weight (kg)	N.D.	1.5	1.5	1.5-1.6	1.38 ± 0.12	1.54 ± 0.14	1.37 ± 0.13
TSS (%)	N.D.	>15	13-14	N.D.	12.5 ± 1.18	14.1 ± 0.93	13.5 ± 0.56
Blossom (days after seeding)	~50	~50	~50	N.D.	44-45	44-45	44-45
cultivation periods (days)	~100	~100	~100	N.D.	94-95	94-95	94-95
Price (USD)	>200	~60	~45	20-30			

N.D.: no data

Conclusion

- Manipulation of N and K fertilizations
  - **Enhancing fruit qualities** (e.g. weights, sweetness)
  - **Enhancing overall preferences (II)**
- But, excessive K with low-N during FE
  - Reduce **overall preferences** (III)
- Equivalent to mountain class in Japan
  - Success in producing high-quality melons
  - High market price

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ECOLOGY & CONSERVATION LABORATORY

National Taiwan University

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Questions are welcomed

Rita S.W. Yam: ritayam@ntu.edu.tw

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