UPOV
International Union for the Protection of New Varieties of Plants

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Technical Working Party on Testing Methods and Techniques **TWM/3/12**

Third Session
Beijing, China, April 28 to May 1, 2025

Original: English
Date: April 11, 2025

GRADING CRITERIA OF *ANTHURIUM* DUS QUANTITATIVE CHARACTERISTICS BY MULTIPLE COMPARISON

Document prepared by an expert from China

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The annex to this document contains a copy of a presentation “Grading Criteria of *Anthurium* DUS quantitative characteristics by multiple comparison”, to be made by an expert from China, at the third session of the TWM.

[Annex follows]

Technical Working Party on Testing Methods and Techniques
Third Session

上海市农业科学院
SHANGHAI ACADEMY OF AGRICULTURAL SCIENCES

Grading Criteria of *Anthurium* DUS quantitative characteristics by multiple comparison

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2025

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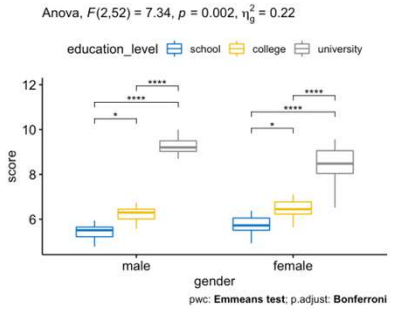
What is Multiple comparisons?

LSD	Highest error rate and power of any method. In general, it controls the FWER in the weak sense; when there are 3 treatment groups, the FWER is controlled in the strong sense.
BF	Controls the FWER in the strong sense, but it is too conservative (reduces the number of true positives).
TK	Lowest error rate and power, control the FWER in the strong-sense
SNK	Error-rate and power intermediate between TK and DMRT. Controls the FWER in the weak sense.
DC	Error-rate and power intermediate between SNK and LSD. Controls the FWER in the weak sense.

The table was taken from Christensen (2011) with some modifications.
BF = Bonferroni; DC: Duncan method; LSD = Least significant difference;
SNK = Student-Newman-Keuls; TK = Tukey Kramer (or Tukey HSD in balanced designs).



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Common grading methods for DUS QN characteristics

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SD method

Reference: Selection and Classification for Amaryllis (*Hippeastrum*) DUS Testing Quantitative Traits

- Grade interval should be greater than 2 ×SD.
- Excellent performance when there are relatively few varieties.

LSD method

Reference: Variation and Distribution of Quantitative Characters of Peanut in DUS Testing

- Grade interval should be greater than $2\times LSD_{0.05}$
- The data must follow a normal distribution.
- Applicable when there are enough varieties.

Equidistant method

Reference: Study on Classification Method for Main Quantitative Characters of Maize DUS Test

- Extreme difference was divided by an equidistant distance.
- No statistical method was used to determine the number of grades.

Probabilistic grading method

Reference: Variation and Probability Grading of Main Quantitative Traits of *Phalaenopsis* Germplasm Resources

- There are 5 levels of 10%, 20%, 40%, 20%, 10%, (X-1.2818S), (X-0.5246S), (X+0.5246S), and (X+1.2818S) with 4 sub-points.
- Or there are 3 levels of 30%, 40%,30% with (X-0.5246S) and (X+0.5246S) 2 points.
- The data must follow a normal distribution.

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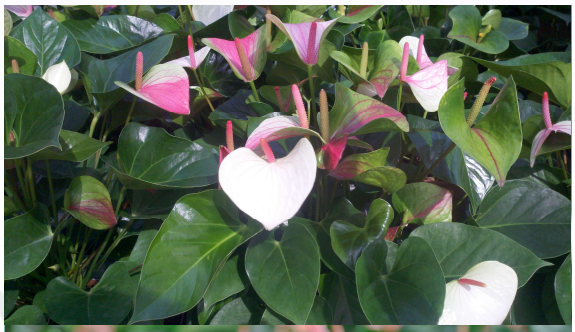
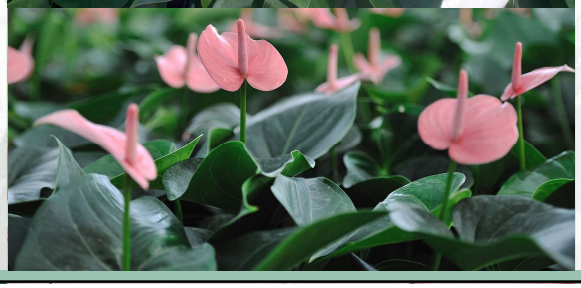
Material and observational characteristics

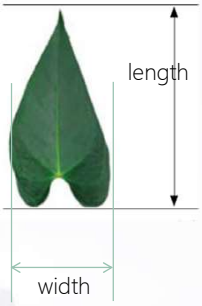
251 varieties





Plant: size
(height+width) /2

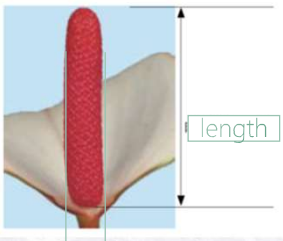
Leaf blade: length
Leaf blade: width
Petiole: length



Peduncle: length
Peduncle: thickness

Spathe: size
(length+width) /2

Spadix: length
Spadix: thickness



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1. Analysis of Variation in Quantitative Characteristics of Anthurium

Table 1. Variations of quantitative characteristics on *Anthurium*.

	Minimum	Maximum	Mean	Median	Average SD	Intra-Variety CV/%
Plant size (cm)	22.95	67.175	39.99	39.34	2.87	7.18
Leaf blade length (cm)	10.36	38.53	19.95	18.84	1.44	7.22
Leaf blade width (cm)	5.25	22.08	11.58	11.09	0.90	7.77
Petiole length(cm)	7.59	49.21	21.86	19.65	2.21	10.11
Peduncle length (cm)	13.40	61.72	31.08	28.97	2.98	9.59
Peduncle thickness (mm)	2.08	6.93	3.91	3.82	0.38	9.72
Spathe size (cm)	4.46	16.29	9.23	9.32	0.83	8.99
Spadix length (cm)	2.13	9.55	4.37	4.17	0.40	9.15
spadix thickness (mm)	3.71	10.30	6.32	6.35	0.44	6.96

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2.Test of Normality of Quantitative Characteristics

Table 2. K-S test of quantitative characteristics

Characteristic			Negative Difference	K-S Value	Sigma Value
Plant: size	0.078	0.078	−0.035	0.078	0.001
Leaf blade: length	0.098	0.098	−0.063	0.098	0.000
Leaf blade: width	0.081	0.081	−0.043	0.081	0.000
Petiole: length	0.152	0.152	−0.082	0.152	0.000
Peduncle: length	0.099	0.099	−0.054	0.099	0.000
Peduncle: thickness	0.065	0.065	−0.035	0.065	0.013
Spathe :size	0.034	0.034	−0.032	0.034	0.200
Spadix: length	0.116	0.116	−0.067	0.116	0.000
Spadix: thickness	0.044	0.044	−0.029	0.044	0.200

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3.Correlation analysis of the quantitative characteristics

Table 3. The correlation coefficient of the nine quantitative characteristics of *Anthurium*.

	Plant Size	Leaf Blade Length	Leaf Blade Width	Petiole Length	Peduncle Length	Peduncle Thickness	Spathe Size	Spadix Length
Plant size	1							
Leaf blade length	0.760 **	1						
Leaf blade width	0.765 **	0.876 **	1					
Petiole length	0.820 **	0.829 **	0.780 **	1				
Peduncle length	0.808 **	0.797 **	0.764 **	0.893 **	1			
Peduncle thickness	0.713 **	0.718 **	0.753 **	0.684 **	0.686 **	1		
Spathe size	0.516 **	0.601 **	0.634 **	0.484 **	0.535 **	0.639 **	1	
Spadix length	0.772 **	0.827 **	0.796 **	0.812 **	0.793 **	0.744 **	0.627 **	1
Spadix thickness at the middle	0.548 **	0.612 **	0.629 **	0.546 **	0.520 **	0.703 **	0.537 **	0.603 **

** Correlation is significant at the 0.01 level (2-tailed).

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4、Grading Criteria of *Anthurium* set by Three Methods

Table 4. The state interval established by three methods, respectively.

	Multiple Comparison Method	SD Method	$LSD_{0.05}$ Method
Plant:size(cm)	6.60–7.00	5.70	5.60
Leaf blade: length(cm)	3.20–3.90	2.90	2.70
Leaf blade: width(cm)	2.10–2.50	1.80	1.80
Petiole: length(cm)	5.00–5.90	4.40	4.30
Peduncle: length(cm)	7.10–7.60	5.90	5.80
Peduncle: thickness(mm)	0.86–1.03	0.75	0.70
Spathe:size(cm)	2.49–2.60	1.70	2.00
Spadix: length(cm)	0.90–1.00	0.80	0.77
Spadix: thickness at the middle(mm)	1.00–1.10	0.87	0.84

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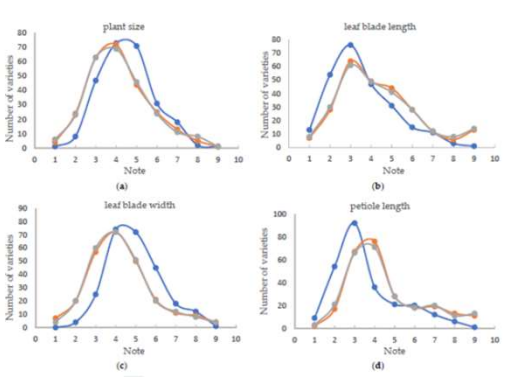

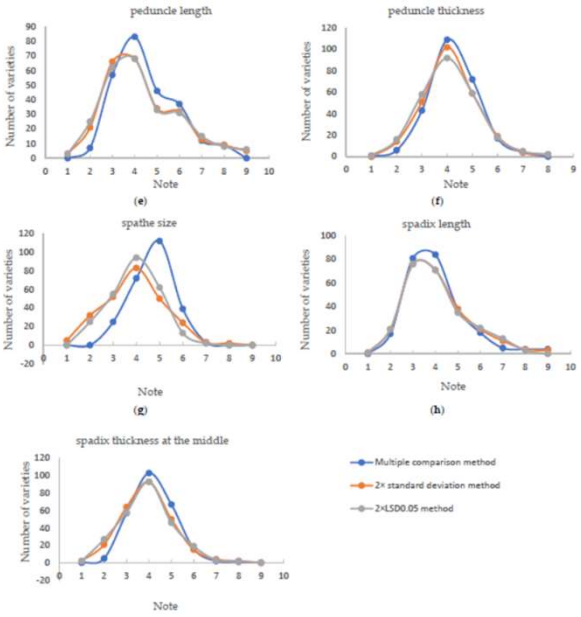

Leaf blade length, petiole length and peduncle length,spadix length and the spadix thickness at the middle are positively skewed.

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5.Effectiveness of Two Grading Criteria Set by SD Method and Multiple Comparison Method

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Table 5. Grading range of quantitative characteristics of *Anthurium*.

Criteria 1(SD method)

Criteria 2(Multiple comparison)

Note	1	2	3	4	5	6	7	8	9
Plant:size(cm)	19.0	26.0	32.9	39.6	46.4	53.0	60.0	67.0	74.0
	13.5	19.2	25.0	30.7	36.5	42.2	48.0	53.7	59.5
Leaf blade:length(cm)	13.1	16.3	19.6	23.1	26.6	30.5	34.0	37.5	41.0
	11.6	14.5	17.4	20.3	23.1	26.0	28.9	31.8	38.7
Leaf blade:width(cm)	4.1	6.2	8.5	10.7	12.9	15.1	17.5	19.6	22.1
	6.6	8.4	10.2	12.0	13.8	15.6	17.4	19.2	22.1
Petiole:length(cm)	7.1	12.2	17.4	23.0	28.0	33.1	38.3	43.4	49.3
	8.6	13.0	17.4	21.9	26.3	30.7	35.1	39.6	49.3
Peduncle: length(cm)	9.5	16.5	24.3	31.3	38.3	45.3	53.0	62.0	69.0
	14.1	20.0	26.0	31.9	37.9	43.9	49.8	55.8	61.8
Peduncle:thickness(mm)	1.5	2.4	3.26	4.12	5.0	5.9	6.93	7.83	8.73
	1.9	2.7	3.4	4.2	4.9	5.7	6.4	7.2	7.9
Spathe:size(cm)	1.2	3.7	6.2	8.71	11.2	13.7	16.3	18.8	21.3
	5.1	6.8	8.5	10.2	11.8	13.5	15.1	16.8	18.4
Spadix: length(cm)	1.96	2.86	3.8	4.8	5.7	6.7	7.7	8.7	9.7
	2.2	3.0	3.8	4.6	5.4	6.2	7	7.8	8.6
Spadix: thickness at the middle(mm)	3.6	4.61	5.61	6.71	7.73	8.8	9.8	10.8	11.9
	4.2	5.0	5.9	6.8	7.7	8.5	9.4	10.3	11.2

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Table 6. Distinguished variety pair proportion with different D-value (%)

Variety Pair	With Same Note	With Same Note	Difference of One Note	Difference of One Note	Difference of Two Notes	Difference of Two Notes	Error Rate	Error Rate
ethod	SD Method	Multiple Comparison Method	SD Method	Multiple Comparison Method	SD Method	Multiple Comparison Method	SD Method	Multiple Comparison Method
Plant:size	2.61	0	52.61	58.41	99.75	100	0.25	0
Leaf blade:length	2.46	0	47.57	60.95	99.20	99.70	0.80	0.30
Leaf blade:width	0.94	0	37.82	51.53	98.34	100	1.66	0
Petiole:length	4.72	0	49.43	61.62	99.66	99.98	0.34	0.02
Peduncle:length	4.37	0	49.60	61.51	99.69	100	0.31	0
Peduncle:thickness	0.63	0	30.31	39.70	98.62	100	1.38	0
Spathe:size	2.97	0	32.60	53.95	81.75	100	18.24	0
Spadix:length	2.03	0	30.55	47.30	98.52	99.98	1.48	0.02
Spadix:thickness at the middle	3.09	0	44.20	54.60	97.24	100	2.76	0
Total	23.84						27.22	0.34

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Thank you!

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