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Field Evaluation on Agronomic Characteristics of Newly Introduced Bitter Gourd (*Momordica charantia* L.) Accessions in Thua Thien Hue Province, Vietnam

The Thi Dieu Nguyen[3], An Thi Do[1] and Hai Thi Hong Truong[1, 2, 3]

1. Agronomy Faculty, University of Agriculture and Forestry, Hue University, 102 Phung Hung Street, Hue City 530000, Vietnam

2. Institute of Biotechnology, Hue University, Tinh Lo 10 Street, Hue City 530000, Thua Thien Hue Province, Vietnam

3. Hue University, 03 Le Loi Street, Hue City 530000, Vietnam

Abstract: The main objective of this study was to evaluate ability of growth and yield of introduced bitter gourd accessions in winter-spring 2016-2017 in Thua Thien Hue province. A total of seven accessions were used in this study. Of these, six accessions were provided by the World Vegetable Center (AVRDC), namely, AVRDC 1329, AVRDC 1330, AVRDC 1331, AVRDC 1333, AVRDC 1334, AVRDC 1335 and one Vietnam local accession (control) from Dien Hai commune, Phong Dien district, Thua Thien Hue province. The results showed that experiment accessions can grow under Thua Thien Hue conditions. AVRDC 1329, AVRDC 1330, and AVRDC 1335 were considered as displaying good growth and development ability. Of those, AVRDC 1330 was the most suitable to consumer as regards to appearance and bitter taste. AVRDC 1330, the control check and AVRDC 1331 had the high actual yield with 16.57, 10.65 and 7.88 tons/ha, respectively, and these two introduced accessions can be used for breeding and cultivation under local condition.

Key words: Bitter gourd, *Momordica charantia* L., agronomic characteristics, World Vegetable Center, Thua Thien Hue.

1. Introduction

Bitter gourd (*Momordica charantia* L.), also known as bitter melon, balsam pear, bitter apple and bitter African or wild cucumber, is a tropical and subtropical vine of the family Cucurbitaceae [1, 2]. Bitter melon is traditionally used as a food and medicine. This fruit does not serve as a staple food, but can be eaten several times a week when in season [3]. The immature fruits and tender vine tips are used in a variety of culinary preparations. The fruits and shoots are soaked in salt water to remove some of their bitterness and then boiled, fried or pickled [4]. In addition, the fruit of bitter gourd is similar in nutritional value compared to other cucurbits, with the notable exception that it is much higher in folate and vitamin C. The vine tips are an excellent source of vitamin A. The medicinal value of this fruit in the treatment of infectious diseases and diabetes is attracting the attention of scientists worldwide [4]. There are a lot of researches conducted on bitter gourd both in agriculture and medicine field. Genetic variability in ascorbic acid and carotenoids content in Indian bitter gourd (*Momordica charantia* L.) was studied by Dey et al. [5]. Dhillon and Phethin [6] reseached variation for bitterness and other fruit traits in bitter gourd (*Momordica charantia* L.) collections. Inhibition of increases in blood glucose and serum neutral fat by *Momordica charantia* saponin fraction was reported by Oishi et al. [7]. Nowadays, many products are produced from different parts of bitter gourd, such as tea (from fruits or leaves), juice and extracts.

In Vietnam, bitter gourd is one of the vegetables which have brought high economic efficiency to

Corresponding author: Hai Thi Hong Truong, associate professor, research field: biotechnology.

farmers in recent years. However, bitter gourd has not been considered as the main crop in Thua Thien Hue. The scale of production is small and scattered. In 2015, this number was about 40 ha, and mainly focused on some communes Dien Hai (Phong Dien district), An Do (Huong Tra town), Quang Thai and Quang Tho (Quang Dien district). The change of weather conditions in winter-spring season causes pests, such as downy mildew and powdery mildew. Besides, fruit morphological traits are very an important factor in the market. The accessions had special appearance, such as ovate shape, many warts, short fruit length and dark green color that are more preferred. Therefore, the purpose of this study was to evaluate agronomical characters of introduced bitter gourd accessions under local conditions.

2. Materials and Methods

2.1 Materials

The study used total of seven bitter gourd accessions, including six accessions obtained from World Vegetable Center (AVRDC 1329, AVRDC 1330, AVRDC 1331, AVRDC 1333, AVRDC 1334, AVRDC 1335) and one local accession (control) collected at Dien Hai commune, Phong Dien district, Thua Thien Hue province (Table 1).

2.2 Experimental Design

The field experiment was conducted during winter-spring season from October 2016 to April 2017 in an open field at An Hoa Ward, located in the North of Thua Thien Hue province. Experiment land was ferralic acrisols. The experiment was laid out in a random complete block design (RCBD) for three replications. The spacing of 1.2 m × 0.5 m was applied in this study. Planting and nursing techniques was based on QCVN 01-153:2014/BNNPTNT guidelines [8].

2.3 Agronomy Characteristic Observed

The data parameters were assessed according to QCVN 01-153:2014/BNNPTNT [8]. Each accession was observed eight plants per replication.

Time of growth was recorded from transplanting to 50% of the plants start flowering, as well as the time of first and last harvesting. Stem including node height, stem diameter and color was collected. Of those, the node height was determined between the 15th and 20th node, and the stem diameter at monthly interval. Leaf parameters were directly obtained in adult leaves. Leaf width was the widest of leaf, leaf length was measured from top of leaf to petiole, and depth of leaf lobe was assessed on different depth levels. Fruit morphological traits were gotten when fruits can be used as vegetables. Shape of longitudinal section, base and apex were determined on appearance. Number of warts and wart depth were assessed by depth of leaf lobe. Fruit length was measured as the distance between the ends of fruit, fruit diameter was the widest of fruit and fruit flesh thickness (cm). Color of stem, leaf and fruit was observed by sensory method. Fruit quality was collected in intensity and Brix degree when harvesting. The intensity of bitterness must be tasted at fleshy middle fruit, while

Table 1 Lists of bitter gourd accessions used.

No.	Name of accession	Place of collection
1	AVRDC 1329	The World Vegetable Center
2	AVRDC 1330	The World Vegetable Center
3	AVRDC 1331	The World Vegetable Center
4	AVRDC 1333	The World Vegetable Center
5	AVRDC 1334	The World Vegetable Center
6	AVRDC 1335	The World Vegetable Center
7	Local accession (control)	Dien Hai commune, Phong Dien district, Thua Thien Hue province

Brix degree was measured on five fruits per replication by refractometer and expressed in average value. Powdery mildew and downy mildew disease were recorded by scoring method. Theory yield and actual yield were calculated as the following Eqs. (1) and (2):

$$\text{Theory yield (tons/ha)} = \frac{\text{number of fruit}}{\text{number of plants}} \times \text{fruit weight} \times \text{plant density} \quad (1)$$

$$\text{Actual yield (tons/ha)} = \frac{\text{yield of experiment plot (tons)}}{\text{plot area (m}^2\text{)}} \times 10^4 \quad (2)$$

2.4 Statistics Analysis

The raw data were synthesized by Excel 2010, while the differences in mean values of each agronomic characteristic among accessions were compared using Statistix 10.0.

3. Results and Discussion

3.1 Time of Growth

Time of growth is an important factor to determine crop season and apply appropriate techniques. Table 2 shows time of growth and development of bitter gourd accessions.

Time from transplanting to appearing the 1st male flower was different among accessions. While AVRDC 1331 had the shortest time with 20 d, followed by control check (32 d) and AVRDC 1334 (37 d). AVRDC 1333 had the longest time with 134 d. Time from transplanting to appearing the 1st female flower ranged from 25 d (AVRDC 1331) to 139 d (AVRDC 1333). The control check and AVRDC 1329 had the same time with 36 d. Harvesting time depends on many factors, such as variety characteristics, weather conditions and techniques, as well as association with the 1st female flower appearance. Namely, the accession has an early female flowering and the 1st harvesting time is also early. AVRDC 1331 had the earliest harvesting time with 32 d, while AVRDC 1333 the longest harvesting time with 146 d.

Almost all the accessions had the last harvest in range of 115 d to 170 d, whereas, AVRDC 1331 and the control check were shorter with 53 d and 75 d, respectively. The last harvest in this study was longer than the study by Le in the North of Vietnam [9], in which the time of last harvest of 34 bitter gourd accessions ranged from 80 d to 100 d.

3.2 Growth Ability

Growth ability of bitter gourd accessions is presented in Table 3. Node height had significant difference among accessions ($P < 0.05$). The control check had the highest node height with 9.94 cm, while the lowest one was AVRDC 1329 with 4.32 cm. Stem diameter ranged from 0.31 cm (AVRDC 1335) to 0.43 cm (control check).

Leaf area by leaf width and leaf length shows growth ability of a variety. These are one of the characteristics that affect photosynthesis capacity of plant. Leaf width and leaf length of the control check

Table 2 Growth period time of bitter gourd accessions.

Accession	Time (d) from transplanting to			
	Appearing the 1st male flower	Appearing the 1st female flower	Harvesting	
			1st	Last
AVRDC 1329	38	36	44	170
AVRDC 1330	51	54	62	116
AVRDC 1331	20	25	32	53
AVRDC 1333	134	139	146	170
AVRDC 1334	37	51	82	115
AVRDC 1335	60	56	74	170
Control	32	36	45	75

Table 3 Growth ability of bitter gourd accessions.

Accession	Node height (cm)	Stem diameter (cm)	Leaf width (cm)	Leaf length (cm)
AVRDC 1329	4.32[d]	0.37[a]	6.24[d]	4.83[f]
AVRDC 1330	8.36[b]	0.39[a]	7.11[c]	5.86[d]
AVRDC 1331	5.72[c]	0.34[a]	7.91[b]	6.76[b]
AVRDC 1333	4.38[d]	0.40[a]	4.92[e]	4.43[g]
AVRDC 1334	7.67[b]	0.39[a]	7.59[b]	6.37[c]
AVRDC 1335	5.52[c]	0.31[a]	6.55[d]	5.27[e]
Control	9.94[a]	0.43[a]	13.68[a]	12.45[a]
$LSD_{0.05}$	1.10	0.12	0.47	0.25

[a-g] Means with different letters in each column indicate significant difference at $\alpha = 0.05$.

Table 4 Stem and leaf morphological traits of bitter gourd accessions.

Accession	Color		Depth of leaf lobe
	Leaf	Stem	
AVRDC 1329	Dark green	Medium green	Deep
AVRDC 1330	Dark green	Medium green	Medium
AVRDC 1331	Medium green	Medium green	Medium
AVRDC 1333	Dark green	Medium green	Deep
AVRDC 1334	Medium green	Medium green	Medium
AVRDC 1335	Dark green	Medium green	Deep
Control	Dark green	Medium green	Medium

were found to be the biggest with 13.68 cm and 12.45 cm, respectively. AVRDC 1333 had the smallest leaf width (4.92 cm) and the shortest leaf length (4.43 cm). The data indicated significant difference among accessions.

3.3 Morphological Traits of Bitter Gourd Accessions

3.3.1 Stem and Leaf Morphological Traits

Green leaf level is an important trait to distinguish among accessions, and can be changed under external factors. Stem and leaf morphological parameters of bitter gourd accessions are presented in Table 4. Leaf color of AVRDC 1329, AVRDC 1330, AVRDC 1333, AVRDC 1335 and the control check had dark green, whereas AVRDC 1331 and AVRDC 1334 were medium green color. All accessions in this study had medium green stem. Depth of leaf lobe was also different. AVRDC 1330, AVRDC 1331, AVRDC 1334 and the control check had medium lobed leaf, while the remained accessions were deep one.

3.3.2 Fruit Morphological Traits

Each accession has different fruit morphological characteristics, which are signals to identify and distinguish among accessions. The indications of bitter gourd fruit also show the economic value of accession. Fruit morphological parameters are presented in Table 5.

Fruit shape was observed in shape of longitudinal section, base and apex. Longitudinal section of fruit had oblong and ovate shape. The control check and AVRDC 1333 was oblong, the other accessions had ovate. Shape of base and apex were different among accessions. AVRDC 1329, AVRDC 1331 and AVRDC 1335 had rounded base, whereas AVRDC 1330, AVRDC 1333, AVRDC 1334 and the control check had acute shape. The control check was acute apex, AVRDC 1331 had rounded one and the remained accessions were obtuse.

Numbers of warts in most accessions were many, except for AVRDC 1331. Wart depth of accessions was different. AVRDC 1330 and AVRDC 1334 had deep wart, the control check had medium one and the other accessions were obtained shallow wart.

Fruit size includes three parameters, such as fruit length, fruit diameter and fruit flesh thickness. This is an important factor to identify fruit weight. Fruit length

Table 5 Fruit morphological traits of bitter gourd accessions.

Accession	Shape of			Number of warts	Wart depth	Fruit length (cm)	Fruit diameter (cm)	Fruit flesh thickness (cm)	Fruit color
	Longitudinal section	Base	Apex						
AVRDC 1329	Ovate	Rounded	Obtuse	Many	Shallow	3.05^{d}	1.65^{c}	0.19^{de}	Dark green
AVRDC 1330	Ovate	Acute	Obtuse	Many	Deep	10.52^{cb}	3.73^{b}	0.51^{c}	Light green
AVRDC 1331	Ovate	Rounded	Rounded	Few	Shallow	9.31^{c}	3.70^{b}	0.74^{b}	Light green
AVRDC 1333	Oblong	Acute	Obtuse	Many	Shallow	4.15^{d}	1.51^{c}	0.14^{e}	Dark green
AVRDC 1334	Ovate	Acute	Obtuse	Many	Deep	11.56^{b}	3.88^{b}	0.49^{c}	Medium green
AVRDC 1335	Ovate	Rounded	Obtuse	Many	Shallow	4.18^{d}	1.75^{c}	0.25^{c}	Dark green
Control	Oblong	Acute	Acute	Many	Medium	25.94^{a}	4.51^{a}	0.86^{a}	Medium green
$LSD_{0.05}$						1.33	0.49	0.08	

[a-e] Means with different letters in each column indicate significant difference at $\alpha = 0.05$.

Table 6 Fruit quality of bitter gourd accessions.

Accession	Intensity of bitterness	Brix
AVRDC 1329	Weak	1.80^{b}
AVRDC 1330	Medium	1.40^{c}
AVRDC 1331	Medium	1.53^{c}
AVRDC 1333	Medium	1.51^{c}
AVRDC 1334	Medium	1.76^{b}
AVRDC 1335	Weak	1.96^{ab}
Control	Medium	2.18^{a}
$LSD_{0.05}$		0.22

[a-c] Means with different letters in each column indicate significant difference at $\alpha = 0.05$.

and fruit diameter among accessions had significant difference. The fruit length ranged from 3.05 cm (AVRDC 1329) to 25.94 cm (the control check). The data in this study were similar to the results reported by Dhillon et al. [10], who conducted the study on 17 bitter gourd entries for two years and found fruit length ranged from 6 cm to 28 cm for year 1 and from 4 cm to 33 cm for year 2. The control check had the largest diameter with 4.51 cm and the smallest one was observed in AVRDC 1333 with 1.51 cm. Fruit flesh thickness is also related with yield and fruit quality. The control check was also the largest fruit flesh thickness with 0.86 cm.

AVRDC 1329, AVRDC 1333 and AVRDC 1335 had dark green fruit color, AVRDC 1330 and AVRDC 1331 were light green, and AVRDC 1334 and the control check had medium green.

3.4 Fruit Quality

Fruit quality is an important factor to increase fruit value. It is expressed by intensity of bitterness and brix degree. Table 6 presents the fruit quality of bitter gourd accessions. Most of the accessions had medium bitterness; whereas, AVRDC 1329 and AVRDC 1335 had weak one. Brix is one of indicators to evaluate fruit quality of bitter gourd. The accession has low intensity of bitterness, the brix will be high. The control check had the highest brix with 2.18; followed by AVRDC 1335 (1.96 °Bx) and AVRDC 1329 (1.80 °Bx), respectively. The lowest brix degree was AVRDC 1330 with 1.40 °Bx. The data indicated significant difference among accessions.

3.5 Yield and Yield Components

Yield and yield components are one of the indicators to evaluate the adaptability of each accession under external conditions. Yield and yield components had significant difference among accessions (Table 7).

Ratio of fruit setting ranged from 11.69% (AVRDC 1331) to 76.14% (AVRDC 1333). The lowest number of fruit per plant was obtained in the control check (3.29 fruits), and AVRDC 1329 had the highest with 60.19 fruits. The data in this study were higher than the study by Dhillon et al. in the World Vegetable Center [11], who conducted on 13 bitter gourd lines and found the number of fruit per plant in the range of 19.00-59.00 fruits/plant. Fruit weight was significant difference among accessions. The control check had the highest weight with 240.33 g, followed by AVRDC 1330 with 97.93 g, and the lowest was AVRDC 1329 with 2.55 g.

Theory yield and actual yield of AVRDC 1330 were the highest with 31.3 tons/ha and 16.57 tons/ha, respectively. The second was the control check with 13.47 tons/ha and 10.65 tons/ha for each parameter. AVRDC 1333 got the lowest theory yield (0.61 tons/ha) and actual yield (0.31 tons/ha).

3.6 Diseases

Disease is a factor that significantly reduces the yield and quality of bitter gourd. Some serious diseases in bitter gourd, such as downy mildew (*Psedoperonospor acubensis*) and powdery mildew (*Erysiphe cichoracearum*) were appeared during the experiment period. Table 8 records level of diseases on bitter gourd accessions.

Downy mildew occurred at the flowering and fruit-bearing stages. *Psedoperonospor acubensis* was observed in AVRDC 1329 and AVRDC 1334. AVRDC 1329 had lower infection than AVRDC 1334 with level 1 and level 3, respectively. Powdery mildew (*Erysiphe cichoracearum*) did not damage in all accessions with disease level of 0.

Table 7 Yield and yield components of bitter gourd accessions.

Accession	Ratio of fruit setting (%)	Number of fruits/plant (fruit)	Fruit weight (g)	Theory yield (tons/ha)	Actual yield (tons/ha)
AVRDC 1329	55.15^{b}	60.19^{a}	2.55^{d}	2.43^{bcd}	1.74^{de}
AVRDC 1330	25.62^{cd}	18.76^{c}	97.93^{b}	31.30^{a}	16.57^{a}
AVRDC 1331	11.69^{e}	10.58^{cd}	74.97^{c}	12.17^{bc}	7.88^{bc}
AVRDC 1333	76.14^{a}	11.73^{cd}	3.24^{d}	0.61^{d}	0.31^{e}
AVRDC 1334	30.69^{c}	3.33^{d}	92.63^{b}	5.25^{bcd}	4.50^{cd}
AVRDC 1335	61.70^{b}	36.03^{d}	3.36^{d}	2.04^{cd}	1.35^{de}
Control	22.16^{d}	3.29^{d}	240.33^{a}	13.47^{b}	10.65^{b}
$LSD_{0.05}$	8.04	9.29	7.84	11.33	3.62

[a-e] Means with different letters in each column indicate significant difference at $\alpha = 0.05$.

Table 8 Diseases level on bitter gourd accessions.

Accession	Downy mildew (*Psedoperonospor acubensis*)	Powdery mildew (*Erysiphe cichoracearum*)
AVRDC 1329	1	0
AVRDC 1330	0	0
AVRDC 1331	0	0
AVRDC 1333	0	0
AVRDC 1334	3	0
AVRDC 1335	0	0
Control	0	0

0 = not infected; 1 = mild disease; 2 = average disease; 3 = moderate disease; 4 = severe disease.

4. Conclusions

AVRDC 1329, AVRDC 1330, AVRDC 1335 and the control check grew well under Thua Thien Hue condition. Almost introduced bitter gourd accessions had special fruit morphological traits that are suitable for the market. AVRDC 1330 and AVRDC 1331 had high actual yield with 16.57 tons/ha and 7.88 tons/ha, respectively. AVRDC 1330 also had good bitter taste and appearance. Downy mildew (*Psedoperonospor acubensis*) was observed in AVRDC 1329 (level 1) and AVRDC 1334 (level 3). Powdery mildew (*Erysiphe cichoracearum*) had not been found on any accessions. There is a need to confirm the growth ability, yield and disease resistance of the two accessions AVRDC 1330 and AVRDC 1331 for further breeding program in Thua Thien Hue.

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