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DEVELOPMENT OF HIGH YIELDING, YEAR-ROUND, SCENTED AND ALMOST SEEDLESS VARIETY OF LEMON

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Abstract

Three lemon germplasms selected from the preliminary evaluation of twenty local and exotic lemons were evaluated in two locations of Bangladesh. Through consequently three years trials, two germplasm viz. LVG-1 and LVG-2 were selected considering their agronomic performance at Mymensingh and Tangail. The LVG-1 and LVG-2 has been collected from Vietnam. It was observed that, LVG-1 was superior to other exotic genotypes and also to check variety BAU Lebu-3, reactions to major diseases and insect pest infestations were also found to be tolerant. During 2015-16, 2016-17 and 2017-18 at Mymensingh, the highest fruit yield per plant (18.1, 19.1, and 20.0 kg), vitamin C content (66.8, 65.1 and 65.9 mg 100 g^{-1}), fruit length (7.7, 8.4 and 8.6 cm), number of fruits $plant^{-1}$ (190.3, 210.3 and 254.6), juice content $fruit^{-1}$ (34.1%, 32.4% and 35.5%) and the lowest seed $fruit^{-1}$ (3 or 2 nos.) was recorded fromLVG-1 from all the three consecutive year and also at Tangail the highest fruit yield per plant (20.6, 19.5, and 20.1 kg), vitamin C content (67.7, 65.7 and 66.1 mg 100 g^{-1}), fruit length (8.2, 8.5 and 7.4 cm), number of fruits $plant^{-1}$ (198.6, 241.6 and 268.6), juice content $fruit^{-1}$ (34.6%, 37.6% and 38.2%) and lowest seed $fruit^{-1}$ (3, 4 and 4 nos.) was recorded from LVG-1compared to LVG-2 and BAU Lebu-3. Considering the better performance of fruit yield, vitamin C content, juice content and less number of seed, LVG-1 genotype was selected as a new variety (Binalebu-1) to cultivate commercially all over Bangladesh.

Key words: Lemon, almost seedless variety, high yield, scented, year round

Introduction

Citrus fruits are very important in respect of their food values, especially being very rich in vitamin C. It is a source of macro and micronutrients (Ting, 1980) and of dietary fiber (Marin *et al.,* 2007). They are also rich in antioxidants compounds (Liu *et al.,* 2012), reveal anticancer, and anti-inflammatory properties (Ma *et al.,* 2020), and are effective at reducing the risk of cardiovascular disease, osteoporosis and type-2 diabetes (Cirmi *et al.,* 2016). It also contains some organic compounds, which work against asthma, antidepressant, stress relief, aids digestion, colds, flu, fever, nosebleeds, mouth ulcers, throat infection and boils (Sfgate, 2017).

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Bangladesh is a country of 168.95 million people and approximately 70% people suffer from malnutrition problem, most importantly different types of vitamins, viz. A, C etc. (Rahman M. and Rahman J., 2014). Reports show that around 93% people of Bangladesh suffer from vitamin C deficiency and unlike other vitamins; it cannot be stored in the body (Mamun *et al.,* 2015). Vitamin C intake of is far below from the recommended dietary allowance (Nielsen, 2000; Hels *et al.,* 2003; Khan and Ahmed, 2005). Thus, intake of vitamin C fruits at regular basis is necessary to maintain the supply of vitamin C in the body.

Despite enormous health benefits of citrus, Bangladesh stands in a very low position in respect of the production of citrus fruits. According to the available statistics, the total area under lemon cultivation was 156440 acres while total production was 58552 M. tons in the year 2019-20 (BBS, 2020). Major lemon producing regions of Bangladesh are Sylhet, Chittagong, and the Chittagong Hill Tracts in the orchards as well as in the homestead areas of many households (Umar *et al.,* 2015). It is, therefore, necessary to give proper attention to increase the production of lemon and to improve their qualities to meet the increasing demand of the people of Bangladesh. The main reasons of low yield are lacking high yielding varieties as well as their traditional cultivation practices. The yield of lemon can be increased through modern high yielding varieties with adopting improved production technologies. Various strategies to increase genetic variability can be pursued by such as seed introduction, hybridization, and mutation (Soeranto, 2011). Introduction as well as selection is one of the main strategies used to improve agronomic traits. In many citrus species, several varieties have developed through selection (Caruso *et al.*, 2020). Hence the objectives of this study were to select a high quality lemon genotype (in terms of size, vitamin C and juice content and seedlessness), year round, tolerant to different abiotic and biotic threats, and with high productivity.

Materials and Methods

Twenty lemon germplasm were collected from home and abroad. Among them LVG-1 and LVG-2 has been collected from Vietnam and selected for their high yielding, year round and seedless characters. Collected genotypes (LVG-1 & LVG-2) along with check variety BAU Lebu-3 were evaluated during three consecutive years (2015-16, 2016-17 and 2017-18) at two different locations viz; Kashiarchar, Mymensingh and Delduwar, Tangail. All the trials were laid out in randomized complete block design with three replications. Pit size was 0.5 × 0.5 m^2 with plant-to-plant distance 2.5 m maintained for all the trials. 20 kg cowdung, 300 g mustard oilcake, 500 g bone meal and 2 kg ash were applied into the pit before planting and after every 3 months 200 g urea, 250 g TSP and 250 g MoP fertilizer was applied to every plant. Intercultural operations as irrigation, weeding, insecticide and fungicide were applied when necessary to ensure normal plant growth and development. Well drainage system was maintained to avoid water logging condition in the experimental site. Data on various characters, such as plant height, fruit length, fruit breath,

individual fruit weight, number of fruits plant^{-1}, juice content fruit^{-1}, rind thickness, number of seed fruits^{-1}, vitamin Ccontent and fruit yield were taken from each plant. The analysis of variance for yield and yield contributing characters of various fruits were done following the principle of F-statistics. Mean comparisons of the treatments were adjudged by the Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results

Results showed significant difference in lemon yield, yield contributing parameters and quality between the evaluated genotypes. Among the genotypes, LVG-1 showed better field performance considering fruit yield plant^{-1}, individual fruit weight, vitamin C content and other important agronomic characters. It was also observed that, LVG-1 was tolerant compare to another genotype and check variety BAU Lebu-3, in cases of reactions to major diseases and insect pest infestations.

Mymensingh

During 2015-16 two germplasm viz. LVG-1 and LVG-2 with check variety BAU Lebu-3 were evaluated at Kashiarchar, Mymensingh. The tallest plant (188.98 cm) was recorded in LVG-1 followed by LVG-2 (176.8 cm) and BAU Lebu-3 (154.6 cm). The fruit length ranged 8.33cm (LVG-1) to 5.32 cm (LVG-2) and fruit breadth was 6.7 cm (BAU Lebu-3) to 4.5 cm (LVG-2). The highest juice fruit^{-1} (34.1%) was recorded fromLVG-1and lowest (21.9%) from BAU Lebu-3. The highest rind thickness (6.63 mm) was obtained from LVG-2 and the lowest rind thickness (4.16 mm) from LVG-1. The highest number of seedfruit^{-1} (15) was found in LVG-2 and the lowest no of seed fruit^{-1} (3) was present in LVG-1. The highest vitamin C content (66.8 mg 100 g^{-1}) was found in LVG-1and the lowest vitamin C content (60.7 mg 100 g^{-1}) was found in LVG-2 followed by BAU Lebu-3 (63.5 mg 100 g^{-1}).Maximum number of fruits plant^{-1} (190.3) was obtained from LVG-1 followed by BAU Lebu-3 (155.7) and LVG-2 (174.7). In case of fruit yield, highest yield (18.1 kg tree^{-1}) was obtained from LVG-1 followed by BAU Lebu-3 (12.1 kg tree^{-1}).

In 2016-17, the tallest plant (197.6 cm) was recorded in LVG-1 genotype at Mymensingh while the shortest plant (172.6 cm) was recorded in BAU Lebu-3. The fruit length ranged 8.4 cm (LVG-1) to 5.6 cm (LVG-2) and fruit breadth was 6.5 cm (BAU Lebu-3) to 5.3 cm (LVG-2). The highest juice fruit^{-1} (32.4%) was recorded from LVG-1 and lowest (22.0%) from BAU Lebu-3. The highest rind thickness (7.34 mm) was obtained from LVG-2 and the lowest rind thickness (4.03 mm) was from LVG-1. The highest number of seeds fruit^{-1} (17) was present in LVG-2 and the lowest number of seeds fruit^{-1} (2) was present in LVG-1. The highest vitamin C content (65.1 mg 100 g^{-1}) was found in LVG-1and the lowest vitamin C content (59.6 mg 100 g^{-1}) was found in LVG-2 followed by BAU Lebu-3 (62.6 mg 100 g^{-1}). In case of fruit yield, highest fruit yield (19.1 kg tree^{-1}) was recorded from LVG-1 and the second highest fruit yield (13.5 kg tree^{-1}) from BAU Lebu-3. The lowest fruit yield (11.5 kg tree^{-1}) was recorded from LVG-2 germplasm.

In 2017-18, the longest plant (217.7 cm) was found in LVG-1 genotype at Mymensingh while the smallest plant (199.6 cm) was recorded in BAU Lebu-3. The fruit length range 8.6 cm (LVG-1) to 5.3 cm (LVG-2) and fruit breadth was 6.7cm (BAU Lebu-3) to 4.5 cm (LVG-2). Maximum no. of fruits plant^{-1} (254.6) was obtained from LVG-1 followed by BAU Lebu-3 (213.6) and LVG-2 (205.6). The highest juice fruit^{-1} (35.5%) was recorded from LVG-1and the lowest (18.8%) from BAU Lebu-3. The highest rind thickness (6.6 mm) was obtained from LVG-2 and the lowest rind thickness (4.1 mm) was LVG-1. The highest number of seeds fruit^{-1} (15) was present in LVG-2 and the lowest number of seed fruit^{-1} (3) was present in LVG-1. The highest vitamin C content (65.9 mg 100 g^{-1}) was found in LVG-1and the lowest (60.2 mg 100 g^{-1}) was found in LVG-2 followed by BAU Lebu-3 (62.9 mg 100 g^{-1}). In case of fruit yield, the highest yield (20.0 kg tree^{-1}) was obtained from LVG-1, the second highest yield (14.4 kg tree^{-1}) was recorded in BAU Lebu-3 and the lowest (12.5 kg tree^{-1}) LVG-2 (Table 1).

Tangail

During 2015-16, two germplasm viz. LVG-1 and LVG-2 with check variety BAU Lebu-3 were evaluated at Deldwar, Tangail. The longest plant (176.8 cm) was recorded in LVG-1 followed by LVG-2 (169.7 cm) and BAU Lebu-3 (154.5 cm). The fruit length ranged 8.8 cm (BAU Lebu-3) to 5.3 cm (LVG-2) and fruit breadth was 5.7 cm (BAU Lebu-3) to 4.8 cm (LVG-2). The highest juice fruit^{-1} (34.6%) was recorded from LVG-1 and lowest (21.2%) from BAU Lebu-3. The highest rind thickness was also obtained from LVG-2 (7.3 mm) and the lowest rind thickness was LVG-1 (4.7 mm). Maximum number of fruits plant^{-1} (198.6) was obtained from Binalebu-1 followed by BAU Lebu-3 (185.3) and LVG-2 (163.5). In case of fruit yield, the highest yield (20.6 kg tree^{-1}) was obtained from LVG-1 and the second highest yield (14.7 kg tree^{-1}) was recorded in BAU Lebu-3 and the lowest (11.8 kg tree^{-1}) from LVG-2.

In 2016-17, the tallest plant (201.4 cm) was recorded in LVG-1 genotype at Deldwar, Tangail followed by LVG-2 (170.7 cm).The highest juice fruit^{-1} (37.6%) was recorded from LVG-1 and lowest (22.1%) from BAU Lebu-3. In case of fruit yield highest yield (19.5 kg tree^{-1}) was found in Binalebu-1 (LVG-1) followed by BAU Lebu-3. The lowest fruit yield (14.7 kg tree^{-1}) was recorded in LVG-2 genotype.

In 2017-18, the significant tallest plant height (215 cm) was found in LVG-1genotype at Tangail, while the smallest plant (174.3 cm) was recorded in BAU Lebu-3. Maximum no. of fruits plant^{-1} (268.6) was obtained from LVG-1 followed by BAU Lebu-3 (246.3) and LVG-2 (215.3). The highest juice fruit^{-1} (38.2%) was recorded from LVG-1 and lowest (20.7%) from BAU Lebu-3. In case of fruit yield, the highest yield (20.1 kg tree^{-1}) was obtained from LVG-1 and the second highest yield (16.4 kg tree^{-1}) was recorded in BAU Lebu-3 (Table 2).

Table 1: Fruit yield, Physicochemical characteristics of three lemon genotypes at Mymensingh during 2015-18

Genotypes	Plant height (cm)	Fruit length (cm)	Fruit breadth (cm)	Individual fruit weight (g)	No. of fruits plant^{-1}	Juice fruit^{-1} (%)	Rind thickness (mm)	Number of seeds fruit^{-1}	Vitamin C (mg 100 g^{-1})	Fruit yield (kg tree^{-1})
2015-16										
LVG-1	188.9a	7.7b	5.1a	121b	190.3a	34.1a	4.16b	3b	66.8a	18.1a
LVG-2	176.8b	5.3c	4.5b	91.8c	174.7b	23.3b	6.63a	15a	60.7b	11.5b
BAU Lebu-3	154.6c	8.3a	6.7a	130a	155.7c	21.9b	5.07a	5b	63.5b	12.1b
2016-17										
LVGI	197.6a	8.4a	5.3b	123b	210.3a	32.4a	4.03b	2c	65.1a	19.1a
LVG-2	181.8b	5.6b	5.3b	111.8c	164.7b	22.9b	7.34a	17a	59.6b	11.5b
BAU Lebu-3	172.6b	9.0a	6.5a	138a	175.9b	22.0b	5.98a	6b	62.6b	13.5b
2017-18										
LVG-1	217.7a	8.6a	5.1b	127.9b	254.6a	35.5a	4.16c	3b	65.9a	20.0a
LVG-2	203.1b	5.3b	4.5b	120.5b	205.6b	23.7b	6.63a	15a	60.2b	12.5b
BAU Lebu-3	199.6b	9.4a	6.7a	143a	213.6b	18.8b	5.07b	5b	62.9b	14.4b

Table 2: Fruit yield, Physicochemical characteristics of three lemon genotypes at Tangail during 2015-18

Genotypes	Plant height (cm)	Fruit length (cm)	Fruit breadth (cm)	Individual fruit weight (g)	No. of fruits plant^{-1}	Juice fruit^{-1} (%)	Rind thickness (mm)	Number of seeds fruit^{-1}	Vitamin C (mg 100 g^{-1})	Fruit Yield (kg tree^{-1})
2015-16										
LVG-1	176.8a	8.2a	5.67a	111.7b	198.6a	34.6a	4.7b	3b	67.7a	20.6a
LVG-2	169.7a	5.3b	4.82b	97.3c	163.5b	24.2b	7.3a	13a	61.4b	11.8c
BAU Lebu-3	154.5b	8.8a	5.69a	127.6a	185.3a	21.2b	6.6a	5b	63.6b	14.7b
2016-17										
LVG-1	201.4a	8.5a	5.70a	109.9b	241.6a	37.6a	4.5b	5b	65.7a	19.5a
LVG-2	170.7b	5.5b	4.63b	119.3b	213.6c	23.9b	5.0a	14a	59.4b	14.7b
BAU Lebu-3	158.5b	8.90a	5.59a	138.9a	228.4b	22.1b	4.6b	6b	61.6b	15.8b
2017-18										
LVG-1	215a	7.4b	5.54a	118c	268.6a	38.2a	4.1a	5b	66.1a	20.1a
LVG-2	184.4b	5.2c	4.35b	129b	215.3c	20.6b	5.1b	11a	61.4b	14.3b
BAU Lebu-3	174.3b	9.1a	5.57a	139a	246.3b	20.7b	5.5b	7b	62.6b	16.4b

The present study revealed that LVG-1 genotype showed better fruit yield, vitamin C, juice content and less seed than LVG-2 and check variety BAU Lebu-3 which is the most important characters to select a suitable variety. LVG-1 performed 30.2%, 4.5% and 23.9% higher fruit yield, vitamin C, juice content and 48.9% lower seed at Mymensingh and 19.6%, 5.9% and 21.5% higher fruit yield, vitamin C, juice content and 28.5% lower seed at Tangail respectively than check variety. Similar variations in fruit characters in lemon cultivars was reported by Arora and Daulta (1991), Fallahi *et al.* (1990) and Prasad et al. (1997). Rashid, 2013 found significant variations in rind thickness, fruit weight in different types of lemon. Kayesh E. *et al.,* (2017) reported year round, broad and seedless fruits of lemon with early flowering. Al-Mouei and Choumane, 2014 stated that variability of the juice contents may be due to the variation of the genetic potentiality of individual genotype. According to Shrestha *et al.* (2012) a seedless variety of citrus contained highest juice. So, the LVG-1 genotype can be select as a new variety for high yielding, year-round, scented and almost seedless variety.

The incidence of Citrus greening, Gummosis and Scab, and insect (Aphid, Citrus leaf miner and Citrus butterfly) infestation were also studied in different locations under field conditions. The advance line LVG-1was found to be tolerant to Citrus greening, Gummosis and Scab diseases and also showed lower infestation by insects. Overall infestation caused by leaf feeder insects like aphid, Citrus leaf miner and Citrus butterfly were lower in LVG-1 genotype compared to the check varieties. The present results are in agreement with the results of Prasad *et al.* (1997) (Table 3).

Table 3.**Reaction of diseases and insect-pest on lemon genotypes**

Genotypes	Disease			Insect infestation		
	Citrus greening	Gummosis	Scab	Aphid	Citrus leaf miner	Citrus butterfly
LVG-1	T	T	MT	T	MT	T
LVG-2	MT	S	S	MT	S	MT
BAU Lebu-3	MT	MT	MT	MT	S	MT

S = Susceptible, MT = Moderately Tolerant, T = Tolerant.

The overall performance of LVG-1genotype was better in different parameters in the consecutive three years trails at two different locations of Bangladesh. Considering the above parameters BINA apply to the National Seed Board (NSB) of Bangladesh for the registration of this genotype as a high yielding lemon variety proposed as Binalebu-1. The NSB registered LVG-1as new variety Binalebu-1 in 2019 for commercial cultivation in Bangladesh.

The salient characters of this lemon are:

- High yielding, year round, scented and all most seedless variety
- Mostly oval to cylindrical in shape, fruit tip acute and fruit surface smooth
- 2-5 seeds contain in a mature fruit but most of the fruits are seedless

- Average single fruit weight: 100-130 g
- Thickness of fruit skin: 4.1-4.7mm
- 38% juice contain in a mature fruit
- First fruiting duration: 10-11 months
- Vitamin C content is 67 mg/100 g fruit weight
- This variety is tolerant to citrus greening disease

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