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Binalebu-3: A HIGH YIELDING, YEAR-ROUND, SCENTED AND SEEDLESS VARIETY OF LEMON

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Abstract

An investigation was carried out in three consecutive years at the Horticulture Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh to characterize lemon germplasm for varietal development. The germplasm CL-0021 and CL-0027 were collected from Darziling, India. These two germplasm alone with check variety were evaluated during 2017-18, 2018-19 and 2019-20 at two locations viz. Kashiar char, Mymensingh and Garobazar, Madhupur, Tangail. The experiments were carried out following randomized complete block design with three replications. BAUlebu-4 was used as a check variety in the experiments. CL-0021 was found to be superior to other exotic genotype and check variety in case of fruit setting, disease and disease resistant. During 2017-18, 2018-19 & 2019-20 at Mymensingh, the highest fruit yield plant^{-1}(55.50, 42.23 kg and 33.01 kg respectively), vitamin C (88.15, 88.21and 88.14 mg 100 g^{-1}), plant height (225.55 cm, 189.11 cm and 165.01 cm), fruit length (7.92, 7.71 and 7.69 cm), fruits plant^{-1} (250.00, 2014.24 and 150.00), juice content fruit^{-1} (48.00%, 46.22% and 44.74%) and the lowest seeds fruit^{-1} (4.2,4.1, and 4) was recorded from CL-0021 in all the three consecutive year trials. Similar results were also observed at Garobazar, Madhupur, which was higher compared to CL-0027 and BAUlebu-4 at both locations. The lowest fruit yield, vitamin C, seeds fruit^{-1} observed at CL-0027 at both locations. Considering the better performance of fruit yield, vitamin C content, juice content and less seeds fruit^{-1} compare to CL-0027 and BAUlebu-4; CL-0021 genotype was selected as a new variety naming Binalebu-3 to grow commercially all over Bangladesh.

Keywords: Lemon, Seedless variety, High yield, Scented, Year-round.

Introduction

Lemon (*Citrus limon* L.) is one of the most popular fruit crop under the genus Citrus. The genus Citrus is the world's leading tree-fruit crop belongs to the subfamily Aurantioidae, family Rutaceae and order Sapindales. Different hypotheses have been formulated on the origin of Citrus. In general, Citrus is believed to have originated in the tropical and subtropical regions of Southeast Asia and then spread to other continents. Hodgson (1967) reported that lemon is originated in North -Eastern India and Burma and grown throughout the world. Bangladesh is blessed with a huge diversity of fruits and circa, 72 types of fruits are grown all over the country (Hussain *et al*., 2011). To meet the mineral requirements and to strengthen body defense mechanisms against various biotic and abiotic stresses and for proper health, per capita fruit requirement is 115g. (Rahman and Rahman, 2014). Citrus fruits are very important in respect of their food values, especially being very rich in vitamin C. It is a source of macro

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and micronutrients (Ting, 1980) and of dietary fiber (Marin *et al*., 2007). They are also rich in antioxidant compounds (Liu *et al*., 2012), reveal anticancer, and anti-inflammatory properties (Ma *et al*., 2020), and are effective at reducing the risk of cardiovascular diseases, 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). Despite enormous health benefits of citrus, Bangladesh ranks in a very lower position in respect of the production of citrus fruits compare to other citrus fruit growing countries. According to the available statistics, the total area under lemon fruits was 33087acres while total production was 99930.87M tons in the year 2022-2023 (BBS, 2024). Major lemon producing regions of Bangladesh are Sylhet, Chattogram and the Hill Tracts of Rangamati region in the orchards as well as in the homestead areas (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 for low yield are lack of high yielding varieties as well as traditional production technologies. The yield of lemon can be increased through selection of high yielding germplasm as variety(s) along with adoption of 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 for varietal improvement. In many citrus species, several varieties have developed through selection (Caruso *et al*., 2020). Hence the objective of this study was to select a high-quality citrus genotype (in terms of size, vitamin C content, juice yield, and seedlessness), year-round bearing, tolerant or resistant to different abiotic and biotic stresses, and with high productivity.

Materials and Methods

Lemon germplasm CL-0021 and CL-0027 collected from Darziling, India were evaluated in three consecutive years (2017-18, 2018-19 and 2019-20) at Kashiar char, Mymensingh and Garobazar, Madhupur in Tangail district. All the trials were laid out in randomized complete block design with three replications. Pit size was 0.5m × 0.5m with plant-to-plant distance2.5m maintained for all the trials. Twenty kg cow dung, 300g mustard oilcake, 500g bone meal and 2 kg ash were applied in each pit before planting and after every 3 months 200g Urea, 250g TSP and 250g MP fertilizer were applied in every pit. Intercultural operations like irrigation, weeding, application of insecticide and fungicide were followed when necessary to ensure normal plant growth and development. Lemon plant cannot tolerate water logging condition, so maintained well drainage. Data on various characters, such as plant height (cm), fruit length (cm), fruit breath (cm), individual fruit weight (g), fruits plant^{-1}, juice content fruit^{-1}, peel thickness (with slide calipers), seeds fruit^{-1}, vitamin C content following Ranganna (1991), fruit yield, diseases and insects were taken from each plant. The analysis of variance for various fruit yield and yield attributes was done following the F-test. Mean comparison of the treatments were adjudged by the Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Results showed significant difference in lemon yield, yield contributing parameters and quality between the evaluated germplasm (Table 1). Among the germplasm CL-0021 showed better field performance considering fruit yield plant^{-1}, individual fruit weight, vitamin C content and other important agronomic characteristics. From the result, it was observed that CL-0021 was also found tolerant compared to another genotypes and check variety BAUlebu-4 to major diseases and insect pests' infestations.

Kashiar char, Mymensingh

During 2017-18, two germplasm viz. CL-0021 and CL-0027 with the check variety BAUlebu-4 were evaluated at BINA Head Quarters, Mymensingh. The longest plant height (165.01 cm) was recorded in CL-0021 (Proposed Binalebu-3) followed by CL-0027 (153.10 cm) and BAUlebu-4 (155.45 cm). The fruit length and breadth ranged from 6.22 to 7.92cm and 4.77 to 6.66 cm respectively. The highest peel thickness (4.49 mm) and weight of carpel's (92.01 gm) were also obtained from BAUlebu-4 and the lowest rind thickness (3.84 mm) and weight of carpels (40.88 gm) were recorded from CL-0027. Maximum no. of fruits plant^{-1} (150), individual fruit weight (220.11 gm) and vitamin C (88.11 mg/100ml) content were found in CL-001 followed by BAUlebu-4 (125 fruits plant^{-1}, 195.2 gm fruit^{-1} and 65.99 mg/100ml Vitamin C content) and CL-0027 genotype (116 fruits plant^{-1},132.4 gm fruit^{-1} and 55.11 mg/100mlVitamin C content). In case of fruit yield, the highest yield (33.01 kg tree^{-1}) was obtained from CL-0021 and the second highest yield (18.13 kg tree^{-1}) was recorded in BAUlebu-4 as well as the lowest yield (15.31 kg tree^{-1}) was obtained in CL-0027 genotype (Table 1).

In 2018-19, the tallest plant height (198.11cm) was recorded in CL-0021 (Proposed BINAlebu3) genotype at Kashiar char, Mymensingh while the second highest plant height was found in BAUlebu-4 (180.25 cm). In case of fruit yield and vitamin C content, the highest fruit yield (42.23 kg tree^{-1}) and vitamin C content (86.21 mg/100ml) were found in CL-0021 and the second highest fruit yield (23.59 kg tree^{-1}) and vitamin C content (66.14 mg/100ml) were found in BAUlebu-4. The lowest fruit yield (18.25 kg tree^{-1}) and vitamin C content (43.21 mg/100ml) were recorded in CL-0027 genotype (Table 1).

In 2019-20, the tallest plant height (225.55cm) was found in CL-0021(Proposed BINAlebu3) genotype at Kashiar char, Mymensingh while the shortest plant (189.24 cm) was recorded in CL-0027. Maximum fruits plant^{-1} (250.00) was obtained from CL-0021 followed by BAUlebu-4 (205.09) and CL-0027 (187.65). In case of fruit yield and vitamin C content, the highest yield (55.50 kg tree^{-1}) and vitamin C content (88.15 mg/100ml) were obtained from CL-0021 and the second highest fruit yield (37.14 kg tree^{-1}) and vitamin C content (65.62 mg/100ml) were found in BAUlebu-4. The lowest fruit yield (28.97 kg tree^{-1}) and vitamin C content (44.33 mg/100ml) were recorded in CL-0027 genotype (Table 1).

Garobazar, Madhupur, Tangail

During 2017-18, two germplasm viz. CL-0021 and CL-0027 with check variety BAUlebu-4 were evaluated at Garobazar, Madhupur Tangail. The longest plant (167.32 cm) was recorded in CL-0021 followed by BAUlebu-4 (157.12 cm) and the smallest plant CL-0027 (155.31 cm). The fruit length ranged from 5.54 cm (CL-0027) to 7.96 cm (CL-0021) and fruit breadth was 4.71 cm (CL-0027) to 6.5 cm (CL-0021). The highest juice fruit^{-1} (48.11%) was recorded from CL-0021 and the lowest (33.42%) from CL-0027. The highest peel thickness was also obtained from CL-0027 (4.81 mm) and the lowest peel thickness was in CL-0021 (3.99 mm). Maximum number of fruits plant^{-1} (155) was obtained from CL-0021 followed by BAUlebu-4 (130.3) and minimum number of fruits plant^{-1} was in CL-0027 (131). In case of fruit yield, the highest yield (33.79 kg tree^{-1}) was obtained from CL-0021 and the second highest yield (19.11 kg tree^{-1}) was recorded in BAUlebu-4 and the lowest yield (17.11 kg tree^{-1}) was obtained in CL-0027 genotype (Table 2).

In 2018-19, the highest plant (197.7 cm) was recorded in CL-0021 genotype at Garobazar, Madhupur Tangail while the second highest plant was from BAUlebu-4 (179.6 cm). The highest juice fruit^{-1} (51.10%) was recorded from CL-0021 and the lowest (31.21%) from CL-0027. In case of fruit yield, the highest yield (43.65 kg tree^{-1}) was found in (CL-0021) and the second highest fruit yield (24.65 kg tree^{-1}) was recorded in BAUlebu-4. The lowest fruit yield (20.57 kg tree^{-1}) was recorded in CL-0027 genotype (Table 2).

In 2019-20, the tallest plant height (222.64cm) was found in CL-0021 genotype at Garobazar, Madhupur, Tangail, while the shortest plant (190.6 cm) was recorded in CL-0027. Maximum number of fruits plant^{-1} (251.6) was obtained from CL-0021and the minimum number of fruits plant^{-1} CL-0027 (190.3) followed by BAUlebu-4 (202.3). The highest juice fruit^{-1} (49.38%) was recorded from CL-0021 and the lowest (32.29%) from CL-0027. In case of fruit yield, the highest yield (55.21 kg tree^{-1}) was obtained from CL-0021 and the second highest yield (37.37 kg tree^{-1}) was recorded in BAUlebu-4 followed by CL-0027 (30.78 kg tree^{-1}) (Table 2).

The present study revealed that CL-0021 genotype showed better fruit yield, vitamin C, juice content and less seed than CL-0027 and check variety BAUlebu-4, which are the most important characters to select a suitable variety. CL-0021 performed the highest fruit yield, vitamin C content, juice contented 40.0% lower seed at Kashiar char, Mymensingh and the lower values were found at Garobazar, Madhupur, Tangail compared to check variety. So, the CL-002.01 genotype can be selected as a new variety for high yielding, year-round, and seedless variety. Similar results in fruit characters in lemon cultivars were

Table 1. Fruit yield, physio-chemical characteristics of three lemon genotypes atKashiar char, Mymensingh during 2017-18 to 2019-20

	Genotypes	Plant height (cm)	Fruit length (cm)	Fruit breadth (cm)	Individual fruit wt. (gm)	No. of fruits plant^{-1}	Juice fruit^{-1} (ml)	Peel thickness (mm)	No. of seeds fruit^{-1}	Wt. of peel (gm)	Wt. of carpel (gm)	Vitamin C (mg/100g)	Yield (kg tree^{-1})
2017-18	CL-0021	165.01a	7.92a	6.66a	220.11a	150.00a	44.74a	4.11a	4.00b	88.54	81.50	88.11	33.01a
	CL-0027	153.10c	6.51b	4.77c	132.40c	116.00c	30.35b	3.84b	9.00a	59.20	40.88	55.11	15.31c
	BAU lebu-4	155.45b	6.22c	5.62b	195.20b	125.00b	31.14b	4.49a	5.00b	72.50	92.01	65.99	18.13b
2018-19	CL-0021	198.11a	7.71a	6.52a	210.11b	201.00a	46.22a	4.01b	4.00c	87.18	75.26	86.21	42.23a
	CL-0027	176.26b	6.02c	4.64b	125.30c	146.00b	27.42b	3.90b	10.00a	60.61	31.09	43.21	18.25c
	BAU lebu-4	180.25c	6.11b	5.28a	183.24a	165.40c	31.66b	4.51a	8.00b	73.42	79.11	66.14	23.59b
2019-20	CL-0021	225.55a	7.69a	6.55a	222.22b	250.00a	48.00a	4.12b	4.14c	89.05	79.32	88.15	55.50a
	CL-0027	189.24c	5.98c	4.74b	155.50c	187.65b	31.66b	4.12b	12.11a	62.11	56.15	44.33	28.97b
	BAUlebu-4	211.57b	6.28a	5.88a	191.0a	205.09	33.02b	4.50a	11.02b	74.99	84.33	65.62	37.14b

Table 2. Fruit yield, physio-chemical characteristics of three lemon genotypes at Madhupur, Tangail during 2017-20

	Genotypes	Plant height (cm)	Fruit length (cm)	Fruit breadth (cm)	Individual fruit wt. (gm)	No. of fruits plant^{-1}	Juice fruit^{-1} (ml)	Peel thickness (mm)	No. of seeds fruit^{-1}	Wt. of peel (gm)	Wt. of carpel (gm)	Vitamin C (mg/100g)	Yield (kg tree^{-1})
2017-18	CL-0021	167.32a	7.96a	6.5a	218.71a	155.0a	48.11a	4.01b	4.10b	86.15a	80.32a	87.94a	33.79a
	CL-0027	155.31b	5.54b	4.71b	136.15c	125.2b	33.42b	3.99b	10.23a	57.12b	45.15b	53.50c	17.11b
	BAU lebu-4	157.12b	6.19a	5.60a	191.18b	130.3b	34.11b	4.81a	11.65a	73.99a	84.00a	63.70b	19.11b
2018-19	CL-0021	197.7a	7.88a	6.55a	218.7a	199.6a	51.10a	4.12a	4.20b	88.24a	74.70b	88.01a	43.65a
	CL-0027	173.2b	5.12b	4.7b	135.4c	152.6c	31.21b	3.95b	11.21a	69.52c	28.95c	44.89c	20.57b
	BAU lebu-4	179.6b	6.88a	5.32a	189.5b	170.3b	32.80b	4.58a	12.33a	71.90b	86.84a	65.72b	24.65b
2019-20	CL-0021	222.64a	8.78a	6.60a	220.9a	251.6a	49.38a	4.22b	4.00c	90.65a	75.47a	88.15a	55.21a
	CL-0027	190.26b	5.9c	4.82b	162.22c	190.3c	32.29b	4.32b	10.00a	65.89c	52.15b	41.00c	30.78b
	BAUlebu-4	228.79b	6.32b	5.94a	185.32b	202.3b	33.44b	4.72a	9.00b	74.91b	78.11a	65.10b	37.37b

reported by Fallahi *et al*. (1990) and Prasad *et al*. (1997). Kayesh *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. Shrestha *et al*., (2012) stated that a seedless variety of citrus contained the highest juice. So, the CL-0021 genotype can be selected as a new variety for high yielding, year-round 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 CL-0021 was 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 CL-0021 genotype compared to the check varieties (Table 3). Reaction of fungal diseases and insect-pest infestations of lemon genotypes were done during the experimental period at Kashiar char, Mymensingh and Garobazar, Madhupur, Tangail.

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

Genotypes	Disease reaction			Insect infestation		
	Citrus greening	Gummosis	Scab	Aphid	Citrus leaf miner	Citrus butterfly
CL-0021	T	T	MT	T	MT	T
CL-0027	MT	S	S	MT	S	MT
BAUlebu-4	MT	MT	MT	MT	S	MT

N.B.: S means susceptible, MT means moderately tolerant, and T means tolerant.

Main distinguishing characteristics of new lemon variety Binalebu-3 (CL-0021) which makes the variety different from other varieties:

- High yielding, year-round and seedless variety
- 4-5 seeds contain in a mature fruit but most of the fruits are seedless
- Average single fruit weight: 210-222 g
- Thickness of fruit peel: 4-4.2 mm
- 44-51 ml juice is contained in a mature fruit
- Vitamin C content is 86-88mg100 g^{-1} fruit weight,
- 150-251 fruits bearing from 2 years old plant.
- This variety is tolerant to citrus greening disease
- Average fruit yield 33-55 kg $tree^{-1}$

Conclusion

The overall performance of CL-0021genotype was better for different parameters mentioned above in three consecutive years' trails at two different districts of Bangladesh. So, it was decided to apply for the registration of this genotype as a high yielding variety named Binalebu-3 to the National Seed Board (NSB) of Bangladesh. Consequently, the NSB registered CL-0021 as Binalebu-3 in 2021 for commercial cultivation in Bangladesh.

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