Ann. Bangladesh Agric. (2012) 16 (2): 105-121 *ISSN 1025-482X*

CHARACTERIZATION OF TWENTY PUMMELO GENOTYPES

M. A. Hoque and M. M. Hossain

Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706

Abstract

A study was conducted at the pummelo orchard of RARS, BARI, Akbarpur, Moulvibazar and laboratories of BSMRAU during September, 2007 to October, 2009 with 20 pummelo genotypes comprising BARI Batabi Lebu-1 as check variety to characterize and select superior genotype(s). It is noted that tree shape, growth habit, plant and leaf characters varied in the genotypes. Flowering initiated in middle of December and lasted upto second week of April. Flower characters also varied. In most cases, it took 240 days from flowering to harvest. The genotype CG-5 produced maximum (113.7) and CG-134 had minimum (15.3) numbers of fruits/plant. CG-12 and CG-24 obtained the haviest (1261.5g) and the lowest (552.4g) fruit weight, respectively. CG-18 obtained the toomost yield/plant (81.5kg) followed by CG-5 (81.0 kg), CG-12 (61.0 kg) and CG-185 (60.1 kg), respectively. CG-1 (10.0%), CG-4 (9.3%), CG-18 (12.0%), CG-20 (10.0%), CG-151 (9.5%) and CG-185 (10.2%) had equal or more TSS than the check (9.3%). Number of seeds per fruit ranged 23-148. Weight of 100 seeds differed from 19.0 to 49.7g. However, CG-1, CG-4, CG-10, CG-18, CG-20, CG-134, CG-151 and CG-185 were found better in respect of yield, pulp colour, pulp texture, pulp firmness, weight of pulp, juiciness, juice content, taste, bitterness and TSS as compared to check.

Keywords: Pummelo, *Citrus grandis*, Characterization.

Introduction

Pummelo is an important fruit rich in vitamin C and is a good source of vitamin A and B (Randhawa and Srivastava, 1986). It is grown easily. It can tolerate drought and has lower pest infestation (Rashid et al., 1987). Fruit is palatable; its rind contains essential oils which are used in the cosmetic industry. Fresh ripe fruits are eaten directly and used in preparing various kinds of processed products, such as, jam, jelly, pickle, cake and drink (Azmatullah et al., 1987). Pummelo has also medicinal values (Hodgson, 1967). Fruit has a longer natural shelf life due to its thick rind. Besides, it has export potential specially in countries with ethnic population, both in the fresh and processed form (Anon., 2009).

In Bangladesh, pummelo is cultivated in an area of about 4500 ha with yearly production of 14000 metric tons and average yield is only around 3.0 t/ha (Anon., 2009). It is number one (in production) among the citrus fruits grown in Bangladesh (Rashid et al., 1987). It is grown well in Bangladesh but covers a relatively larger area in the Sylhet region (Anon., 2003).

At present, there are only four pummelo varieties released by BARI. These varieties have been developed through selection from germplasm with high yield potential and good bearing ability. But it is not possible to obtain all the desired traits from these varieties. So, for the improvement of pummelo, we need to find out more new varieties that are superior to the existing varieties. Because, there is a tremendous amount of variability within the genus or species with which the breeder can work that provide even a wider selection of characters (Janick and Moore, 1996). Selection is one of the methods to develop improved variety (ies) from the existing gene pool. Therefore, it is necessary to collect maximum genotypes from home and abroad to enrich the gene pool for variety improvement programme. Incidentally, there are some collections of local pummelo genotypes at the Regional Agricultural Research Station (RARS), BARI, Akbarpur, Moulvibazar. These genotypes were collected time to time from different parts of Bangladesh by arranging "Pummelo Fruit Show". Thus, there is a good scope of selecting superior clone(s) to the existing varieties. Therefore, the present investigation was undertaken with the following objectives:

1. To characterize the existing collected pummelo genotypes and
2. To select superior genotype(s).

Materials and Methods

An investigation was carried out at the RARS, Akbarpur, Moulvibazar of Bangladesh Agricultural Research Institute (BARI) during September, 2007 to October, 2009. A good number of promising pummelo genotypes were identified from the Rajshahi division through a "fruit show" held in August 1984 at RARS, Ishwardi. Those promising genotypes were collected and planted at RARS, Moulvibazar during 1985 to 1988. Out of which, nine genotypes viz. CG-1, CG-4, CG-5, CG-9, CG-10, CG-12, CG-18, CG-20 and CG-24 were selected randomly for the present investigation. Another pummelo show was organized in 1996 at RARS, Akbarpur, Moulvibazar. A number of promising genotypes from the Sylhet division were identified in the show. Those were collected and

planted in 1998. From that collection, 10 genotypes viz. CG-134, CG-135, CG-143, CG-144, CG-151, CG-171, CG-173, CG-182, CG-183 and CG-185 along with the previous nine genotypes were selected for the present study. The released variety BARI Batabi lebu-1 (BB-1) was used as check. All the plants were grown in the orchard with a spacing of 6.0m X 6.0m. Recommended doses of fertilizers were applied properly. Irrigation, weeding and other intercultural operations were done as and when necessary for healthy growth of the plants. Data on different plant, leaf, flower and fruit characters were recorded from the selected genotypes during the investigation period as stated in Citrus Descriptors (IPGRI, 1999). Ten randomly selected leaf, flower, fruits and seeds were taken for recording data. The collected data were analysed by MSTATC programme and means were separated by using Least Singificant Difference (LSD) test.

Results and Discussion

The results are presented below under the following heads:

Plant and leaf characteristics

Plant and leaf characteristics in different genotypes of pummelo are presented in Table 1. Regarding tree shape, most of the genotypes were ellipsoid shape followed by spheroid and obloid. Among 20 genotypes studied, 10 genotypes produced erect type plant, six produced spreading and four had drooping type plant. Hodgson (1967) reported that pummelo plants are either spreading or drooping type, whereas, Singh (1995) and Anon., (2002) reported that pummelo trees are of spreading type.

Plant height in the genotypes ranged from 3.8m to 8.5m (Table 1). The highest plant height was recorded in CG-4 (3.8m) and the lowest in CG-1 (8.5m). Plant height is an important factor in respect of fruit harvest and intercultural operations. It is noticed that plant height was the lowest in the drooping type, whereas, erect type produced comparatively longer plant. Plant height in all the genotypes except CG-4, CG-5, CG-9 and CG-10 was lower than the check variety BARI Batabi lebu-1 (6.9m). Hossain (1983) recorded 1.83m-1.40m height in five years old pummelo trees. Many workers recorded 5-15m plant height in pummelo (Rahman and Khan, 2003; Purseglove, 1987; Azmatullah 1987; Morton, 2006 and Singh, 1995). Canopy diameter is an important issue that determines the spacing of a genotype. In general, drooping type plant had wider canopy diameter. Canopy diameter ranged from 17.5m

Table 1. Plant and leaf characters in different genotypes of pummelo at RARS, Akbarpur

Genotype	Tree shape	Growth habit	Plant height (m)	Canopy diameter (m)	Base girth (cm)	Leaf lamina shape	Leaf apex	Petiole wing shape	Leaf lamina		Petiole	
									length (cm)	width (cm)	length (cm)	width (cm)
CG-1	Obloid	Drooping	3.8	25.3	60	Ovate	Rounded	Obovate	11.9	6.0	1.9	0.6
CG-4	Ellipsoid	Drooping	8.5	19.3	92	Obovate	Rounded	Obovate	12.5	6.5	1.9	0.6
CG-5	Ellipsoid	Erect	8.0	18.3	67	Obovate	Rounded	Obdelate	13.4	6.0	2.2	0.8
CG-9	Ellipsoid	Erect	7.6	17.8	56	Ovate	Acute	Obcordate	13.7	6.4	3.0	1.5
CG-10	Ellipsoid	Erect	7.5	19.3	83	Ovate	Rounded	Obcordate	11.4	5.0	2.5	1.3
CG-12	Ellipsoid	Erect	5.6	20.0	80	Obovate	Rounded	Obcordate	10.0	5.3	2.2	1.1
CG-18	Obloid	Drooping	4.6	26.3	59	Obovate	Rounded	Obovate	11.4	6.2	1.5	0.4
CG-20	Obloid	Drooping	5.6	17.8	64	Elliptic	Acute	Obovate	11.8	5.7	1.7	0.8
CG-24	Ellipsoid	Erect	6.0	20.3	76	Ovate	Rounded	Obcordate	12.3	6.3	3.5	2.3
CG-134	Ellipsoid	Erect	4.5	18.9	40	Ovate	Acuminate	Obcordate	15.3	6.9	4.3	3.9
CG-135	Spheroid	Erect	5.0	17.5	40	Ovate	Acuminate	Obcordate	14.3	6.3	3.3	3.5
CG-143	Spheroid	Spreading	5.0	19.3	55	Obovate	Acuminate	Obcordate	13.9	7.4	3.5	2.2
CG-144	Ellipsoid	Erect	6.1	17.6	55	Obovate	Rounded	Obcordate	14.7	6.8	4.5	3.5
CG-151	Spheroid	Spreading	5.0	19.9	55	Ovate	Rounded	Obcordate	16.2	6.9	4.3	2.6
CG-171	Ellipsoid	Erect	4.3	18.7	47	Elliptic	Acute	Obdelate	11.1	5.3	4.6	2.9
CG-173	Spheroid	Spreading	4.0	17.8	44	Lanciolate	Rounded	Obdelate	13.9	6.9	3.5	2.0
CG-182	Spheroid	Spreading	5.6	18.8	45	Ovate	Acuminate	Obdelate	11.2	5.7	3.5	2.4
CG-183	Ellipsoid	Spreading	6.0	20.0	45	Elliptic	Rounded	Obcordate	12.4	5.3	3.2	2.3
CG-185	Obloid	Spreading	4.5	20.3	50	Lanciolate	Acute	Obdelate	12.6	5.8	2.6	1.4
BB-1	Ellipsoid	Erect	6.9	18.5	53	Ovate	Acute	Obdelate	13.8	6.3	3.3	2.5
Mean	-	-	5.705	19.585	58.3	-	-	-	12.9	6.15	3.05	1.93
CV%	-	-	14.3	8.5	13.9	-	-	-	8.3	9.4	13.2	18.3
LSD0.05	-	-	0.09	1.85	9.25	-	-	-	11.7	0.32	0.29	0.53

Means followed by same letter(s) in the same column do not differ significantly at 5% level by LSD.

(CG-135) to 26.3m (CG-18) in the genotypes, whereas CG-1 and CG-18 had the canopy diameter above 20m. Base girth in the genotypes varied from 40-92cm. A base girth of 13-77cm was recorded by Anon., (1999) in 48 lines of pummelo; whereas, Azmatullah et al., (1987) recorded a range of 16.3-21.6cm base girth in the studied pummelo genotypes. It might be due to the difference in age of plants.

While studying leaf characters, different shapes of leaf lamina such as ovate, obovate, elliptic and lanciolate were observed in the genotypes. Leaf apex was rounded in most genotypes and some were acute or acuminate. Petiole wing shape in around 50% of the studied genotypes was obcordate with some obdelate or obovate (Table 1).

Length of leaf lamina varied from 10.0 cm (CG-12) to 16.2 cm (CG-151). Leaf lamina length was found closer to the check (13.8) in the genotypes CG-5 (13.4 cm), CG-9 (13.7 cm), CG-135 (14.3 cm), CG-143 (13.9 cm), CG-144 (14.7 cm) and CG-173 (13.9 cm). Leaf lamina width ranged from 5.0 cm in CG-10 to 6.9 cm in CG-151 and CG-173. Petiole length in the genotypes varied from 1.5cm to 4.6cm and petiole width varied from 0.4cm to 3.9cm (Table 1). Variation in leaf characters in pummelo were also reported by different authors (Hossain, 1983; Bose et al., 2001; Azmatullah et al., 1987 and Anon. 2002).

Flower Character

Data on different flowers characters of studied pummelo genotypes are presented in Table 2. Flowering was observed mainly from January-February to March-April. Number of petals per flower varied from 3.8 to 4.6. Azmatullah (1987), Hossain (1983) and Morton (2006) reported 4-5 petals in pummelo, whereas and Webber and Batchelor (1948) reported five petals in pummelo. But, Mondal and Amin (1990) stated 4-8 petals and sepals in pummelo.

Number of stamen was above 30 in all the genotypes except CG-1 and CG-135. It was similar to the findings of Mondal and Amin (1990) but differed with those of Webber and Batchelor (1948) and Singh (1995), where they found 20-25 stamens in pummelo. The variation might be attributed to genetic differences. Stamen and style length alongwith diameter of style also varied in the genotypes. Length and diameter of ovary ranged from 0.43 to 0.60 cm and from 0.43 to 0.51cm, respectively. Pollen diameter varied from 35 to 40 micro-meters and percentage of viable pollen ranged 85-99 (Table 2). Frost and Soost (1968) measured pollen diameter within 34-36 micro-meters in lemon.

Table 2. Flower characters of different pummelo genotypes at RARS, Akbarpur

Genotype	Flowering time		Number of petal/ flower	Stamen		Style		Ovary		Pollen diameter (μm)	Viable pollen (%)
	Start	End		Number	Length (cm)	Length (cm)	Diameter (cm)	length (cm)	diameter (cm)		
CG-1	February	April	4.4	29.6	1.36	0.84	0.25	0.47	0.50	38	97
CG-4	February	2nd April	4.0	31.0	1.50	0.85	0.21	0.49	0.43	36	94
CG-5	February	2nd April	4.0	31.0	1.34	0.84	0.22	0.45	0.44	36	95
CG-9	January	March	4.0	32.0	1.58	0.83	0.22	0.45	0.44	37	96
CG-10	February	4th March	4.2	30.6	1.30	0.80	0.25	0.45	0.44	40	99
CG-12	February	March	4.0	33.0	1.38	0.85	0.23	0.46	0.44	38	98
CG-18	January	March	4.0	30.4	1.26	0.86	0.22	0.44	0.43	37	97
CG-20	February	1st April	4.0	30.0	1.35	0.85	0.23	0.46	0.44	38	95
CG-24	January	March	4.0	32.2	1.92	0.90	0.23	0.47	0.44	38	98
CG-134	February	April	4.0	30.0	1.53	0.96	0.26	0.43	0.46	35	94
CG-135	February	1st April	3.8	29.0	1.56	0.99	0.25	0.45	0.46	36	94
CG-143	4th Dec.	4th Feb.	4.0	32.6	1.62	0.87	0.25	0.60	0.46	39	92
CG-144	4th Dec	1st March	4.4	33.2	1.44	0.94	0.24	0.50	0.47	38	94
CG-151	Mid Dec.	4th Feb	4.0	32.8	1.80	0.87	0.29	0.47	0.50	39	94
CG-171	February	Last Mar.	4.0	33.0	1.70	1.05	0.25	0.47	0.46	38	97
CG-173	January	April	4.0	32.0	1.56	0.97	0.29	0.51	0.46	40	93
CG-182	February	1st April	4.0	31.8	1.76	0.89	0.25	0.47	0.45	40	92
CG-183	February	March	4.6	33.0	1.92	1.12	0.26	0.44	0.44	38	94
CG-185	January	Last Mar.	4.4	33.2	1.60	0.91	0.32	0.47	0.51	39	85
BB-1	January	March	4.0	30.0	1.35	0.84	0.21	0.46	0.44	35	95
Mean	-	-	4.09	31.52	1.54	0.90	0.25	0.47	0.46	37.75	94.65
CV%	-	-	20.4	13.5	7.7	11.1	8.7	12.9	13.5	14.2	11.5
LSD0.05	-	-	ns	ns	0.21	0.12	ns	0.11	ns	ns	4.52

Means followed by same letter(s) in the same column do not differ significantly at 5% level by LSD.

Fruit and seed characters

Data on fruit length and diameter as well as other characters of 20 pummelo genotypes are presented in Table 3. Fruit length varied in the genotypes from 10.2 cm to 14.2 cm and diameter from 10.0 cm to 14.1 cm. Regarding fruit size, CG-12 produced the largest (15.0cm X 14.8cm) and CG-24 had the smallest fruit (10.2cm X 10.0 cm). Webber and Batchelor (1948), Azmatullah (1987) and Purseglove (1987) reported about variation in fruit size in pummelo. They opined that fruit size may vary depending on location and variety. CG-185 took the longest days (270) followed by CG-151 (255) from flowering to harvest, while, 50% genotypes needed 240 days (Table 3). Several authors reported that pummelo fruits mature within 240-270 days from flowering (Saha, 2005, Azmatullah (1987) and Singh, 1988), while, Azmatullah et al., (1987) found the pummelo fruits to mature from the third week of August to first week of October. Further, they stated that fruits of pummelo varieties Hassaku and Sin Amanatsu matured within 189.1 and 220.9 days from flowering, respectively. Singh (1995) reported a duration of 9 months from flowering to harvest.These variations in maturity times are due to genetic differences.

Number of fruit per plant and weight of individual fruit varied in the genotypes under study (Table 3). CG-5 and CG-134 produced the highest (113.7) and the lowest (15.3) numbers of fruits per plant, respectively with an average of 44.3. Azmatullah et al. (2005) recorded 43-129 fruits in 11 genotypes; while, 100-110 fruits per plant were stated in another report (Azamatullah, 1987). These variations might be due to variety, age of plant, environmental conditions, disease and insect pressure in the production year as well as management practices. Maximum and minimum fruit weight was obtained by CG-12 (1261.5g) and CG-24 (552.4g), respectively. CG- 12, CG-18 and CG-185 had fruit weight above one kg. Different workers reported various individual fruit weight in pummelo. Azmatullah et al., (2005) described that fruits of pummelo varied from 625g to 945g in weight. In another finding, individual fruit weight ranged from 800g to 1800g (Anon., 2003). Ullah et al. (2001) observed a range of 400g to 1300g fruit weight in pummelo. Saha (2005) reported individual fruit weight in pummelo as 955.0g, 762.0g, 1075.0g and 884g in the varieties BARI Batabi lebu-1, BARI Batabi lebu-2, BARI Batabi lebu-3 and BARI Batabi lebu-4, respectively. More or less similar findings were also reported by several workers abroad. Cai (1995) noted

Table 3. Fruit characters in different genotypes of pummelo at RARS, Akbarpur

Genotype	Fruit		Days taken from flowering to harvest	Fruit/ plant (no.)	Weight of fruit (g)	Yield (Kg/plant)	Segment/ fruit (no.)	Wt. of pulp (g)	Vesicle length (cm)	Juice content (g)	Brix (%)	Fruit-pulp ratio
	Length (cm)	Diameter (cm)										
CG-1	11.9	12.6	210	45.3	768.1	34.0	16	477.8	2.6	301.5	10.0	1.60
CG-4	11.4	10.6	240	73.0	591.7	42.6	15	346.3	1.1	255.3	9.3	1.59
CG-5	12.3	11.8	240	113.7	716.4	81.0	15	394.7	2.1	298.0	9.0	1.88
CG-9	12.7	12.1	240	60.7	816.7	48.9	16	330.0	1.9	245.3	8.9	2.45
CG-10	11.3	11.0	210	23.7	584.5	13.6	14	272.0	1.9	189.3	9.0	2.02
CG-12	15.0	14.8	210	49.7	1261.5	61.0	15	465.0	2.0	340.3	9.0	2.60
CG-18	12.0	14.2	240	77.7	1057.5	81.5	16	526.9	2.0	402.8	12.0	1.87
CG-20	10.5	11.2	240	27.7	679.4	18.8	14	399.4	2.3	303.3	10.0	1.60
CG-24	10.2	10.0	240	26.3	552.4	14.1	14	193.2	2.3	128.3	8.0	2.46
CG-134	12.0	13.0	240	15.3	871.1	13.4	14	158.3	1.9	53.0	9.0	5.40
CG-135	13.8	12.8	210	30.0	841.1	24.9	14	234.0	1.9	138.7	9.1	3.42
CG-143	10.4	11.6	240	28.7	705.2	16.1	18	272.0	2.6	184.1	8.2	2.58
CG-144	10.6	11.3	240	40.7	883.6	35.2	16	296.7	1.9	165.0	8.2	2.85
CG-151	11.7	12.2	255	50.7	948.1	45.8	16	480.3	1.4	340.5	9.5	1.80
CG-171	12.1	11.6	210	16.3	750.8	12.0	14	292.8	1.8	212.8	9.0	2.56
CG-173	12.4	11.5	240	30.7	709.9	21.5	15	314.7	2.0	176.9	9.0	2.37
CG-182	12.4	12.6	210	46.3	914.8	40.6	16	448.2	2.3	308.6	8.0	2.16
CG-183	12.6	12.5	210	36.0	794.1	28.4	15	351.2	2.9	248.0	8.9	2.11
CG-185	14.2	14.1	270	60.7	1004.8	60.1	15	581.7	1.8	442.9	10.2	1.71
BB-1	12.3	12.6	240	35.7	933.1	32.8	14	483.8	2.0	314.5	9.3	1.95
Mean	12.1	12.2	232	44.3	819.3	36.3	15.1	365.9	2.03	252.5	9.18	2.35
CV%	10.3	9.9	7.7	13.6	11.2	4.06	9.1	13.5	9.8	8.5	9.8	10.6
LSD 0.05	1.02	0.98	25.6	32.6	136.2	24.41	ns	39.4	0.32	56.3	0.43	0.89

Means followed by same letter(s) in the same column do not differ significantly at 5% level by LSD.

individual fruit weight to range 800-1200g; while, Li (1997) recorded individual fruit weight in the pummelo variety Hongxinyou as 2-5 kg. Like average weight, number of fruit per plant also varied in different years.

Yield per plant (kg) among the genotypes had differences. On an average, yield/plant among the genotypes varied from 12.0 kg (CG-171) to 81.5 kg (CG-18). The highest yield/plant of CG-18 (81.5kg) was statistically similar with those of CG-5 (81.0 kg), CG-12 (61.0 kg) and CG-185 (60.1 kg). Further, CG-4 (42.6 kg), CG-9 (48.9 kg), CG-12 (61.0 kg), CG-151 (45.8 kg) and CG-182 (40.6 kg) produced yields above the average (36.3kg). This variation of yield within the genotypes might be due to their genotypic effect. Similar findings of variable yield in the studied genotypes were also reported by a number of authors (Chen and Rao, 1999; Anon., 2001; Randhawa and Srivastava, 1986, Hossain, 1983; Webber and Batchelor, 1948 and Anon., 2002).

Numbers of segment per fruit in the genotypes varied. The highest number of segments (18) in a fruit was noticed in CG-143; whereas, CG-10, CG-20, CG-24, CG-134, CG-135, CG-171 and the check had the lowest (14). This difference in number of segments/fruit among the cultivars was also stated by Azmatullah et al., (2005), Azmatullah (1987), Rahman and Khan (2003), Ullah et. al., (2001), Morton (2006) and Hossain (1983). Several authors also observed variation in number of segments/fruit within the same cultivar (Webber and Batchelor, 1948; Hodgson, 1967; Zeng, 1999 and Rahman et al., 2005). Weight of pulp in the studied genotypes varied significantly from 193.2g to 581.7g. Vesicle length in the genotypes also varied. The longest vesicle (2.9cm) and the shortest (1.1cm) were noticed in CG-183 and CG-4 (Table 3). A variable amount of juice was obtained in the studied genotypes. CG-185 produced highest amount of juice (442.9 g) followed by CG-18 (402.8g), CG-151 (340.5g), CG-12 (340.3g), respectively. It implies that the genotype were very juicy. It is revealed from the Table 3 that brix (%) in the genotypes varied from 8.0 (CG-24) to 12.0 (CG-18). CG-1 (10.0%), CG-4 (9.3%), CG-18 (12.0%), CG-20 (10.0%), CG-151 (9.5%) and CG-185 (10.2%) had little differences with the check (9.3%). Long (2000) and Ullah et al., (2001) also reported similar results but Azmatullah et al., (1987) found a lower brix range (6.13-8.53%) in pummelo. This might be due to genetic difference. Percentage of brix is an important criterion in selecting a variety. In the present study, the

genotypes that had equal or higher brix (%) than the check might be selected for commercial cultivation if they possess other desired characters. Fruit-pulp ratio is an important factor in pummelo. A fruit-pulp ratio around unity is good. Fruit-pulp ratio among the studied genotypes varied. The highest and the lowest ratios were found in CG-134 (5.34) and CG-4(1.59), respectively. Fruit-pulp ratio below 2.0 was recorded in CG-1 (1.6), CG-4 (1.59), CG-5 (1.88), CG-18 (1.87), CG-20 (1.6), CG-151 (1.8), CG-185 (1.71) and the check (1.95). Ullah et al., (2001), Rahman et al., (2005) and Hossain (1983) also reported similar results in pummelo.

Data regarding rind thickness and percentage of edible portion in different pummelo genotypes are presented in Fig. 1 and Fig. 2, respectively. Rind thickness in the genotypes varied from 0.75 cm in CG-20 to 2.50 cm in CG-135. It is an important issue regarding the quality of pummelo fruit. Thick rind is not favoured by the consumers as it has a negative relation with internal diameter of fruits (Dhillon and Singh, 1993). Variation in rind thickness was observed by different workers which might be attributed to genetic difference. Percentage of edible portion in the genotypes of pummelo also varied. Maximum edible portion (62.9%) was found in CG-4 and minimum (18.5%) in CG-134 (Fig. 2). The higher edible portion was observed in CG-1 (62.5%), CG-4 (62.9%), CG-5 (53.1%), CG-18 (53.4%), CG-20 (62.6%), CG-151 (55.6%) and CG-185 (58.3%) compared to the check.

Fruit shape, skin colour, pulp color, texture, bitterness and seeds of different pummelo genotypes are presented in Table 4. It is revealed from the table that fruit shape in the genotypes were not similar, rather, distinctly different from each other. Shapes were spheroid/ globose/ obloid/ semi-obloid/ cylindrical/ ellipsoid/ semi-pyriform/ pyriform/ oblique. Skin colour in the genotypes had differences, such as, light green, green yellow or light yellow. A special character of red spots in patches on the skin of mature fruits in the genotype CG-182 was noticed. Red colour of pulp in those fruits was observed when cut. Red pulp colour was not found in other fruits of the same plant which were still immature and red patches not yet formed. Intensity of red pulp colour was found to be positively related with the intensity of red colour of patches on the skin. This marker in the genotype CG-182 can be helpful for the consumers to have a pummelo fruit with red pulp. Besides, it is an indicator of high carotene content.

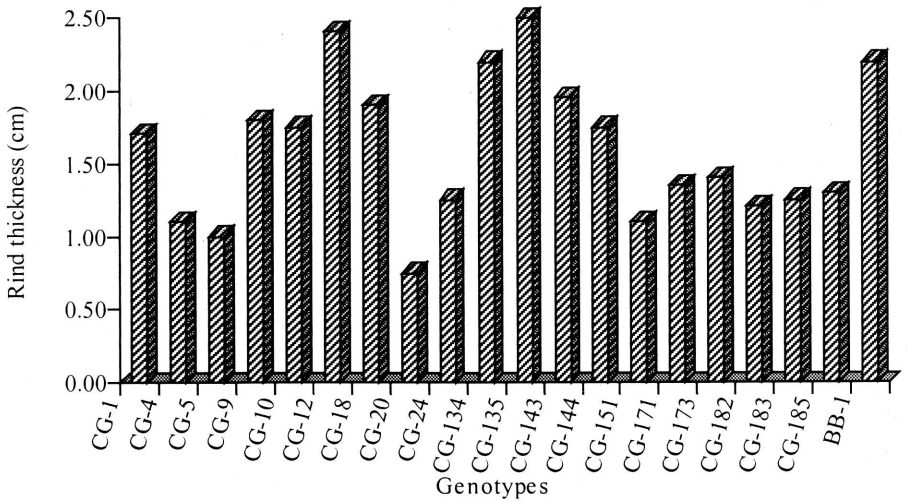

Fig. 1. Thickness of rind of fruit in different pummelo genoatypes at RARS, Akbarpur.

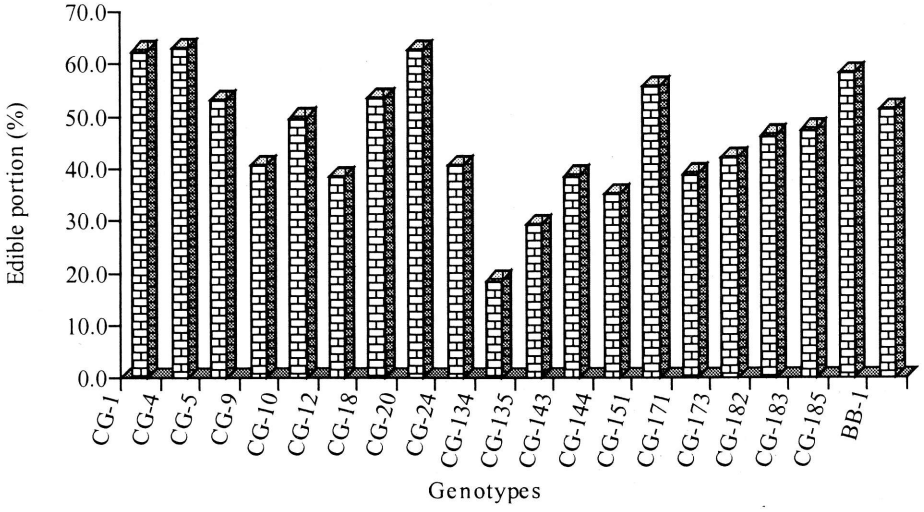

Fig. 2. Percentage of edible portion of fruit in different pummelo genotypes at RARS, Akbarpur.

Table 4. Fruit and seed characters in different genotypes of pummelo at RARS, Akbarpur

Genotype	Fruit shape	Skin colour	Albedo colour	Adherence of albedo to pulp	Pulp colour	Pulp texture	Juiciness	Taste	Bitterness	Seeds/fruit		100 seed wt.(g)
										Number	Weight (g)	
CG-1	Spheroid	Light green	Light pink	Weak	Light red	Fleshy	Very Juicy	Sweet	Low	91.0	33.4	36.7
CG-4	Spheroid	Green	Light pink	Medium	Light pink	Fleshy	Very Juicy	Sweet	Low	77.0	33.6	43.6
CG-5	Globose	Light green	Light pink	Strong	Pink	Fleshy	Very Juicy	Medium sweet	Low	52.0	25.2	48.5
CG-9	Globose	Yellow	White	Medium	Light red	Fleshy	Very Juicy	Medium sweet	Low	143.0	48.1	33.6
CG-10	Spheroid	Green yellow	Greenish	Medium	Light pink	Fleshy	Juicy	Medium sweet	Low	67.0	39.1	58.4
CG-12	Globose	Light green	White	Weak	Light pink	Fleshy	Very Juicy	Medium sweet	Low	88.0	39.1	44.4
CG-18	Obloid	Light yellow	Light pink	Medium	Red	Fleshy	Very Juicy	Sweet	Low	23.0	9.8	42.6
CG-20	Cylindrical	Green yellow	White	Medium	Pink	Fleshy	Very Juicy	Sweet	Low	65.0	27.8	42.8
CG-24	Ellipsoid	Green yellow	Greenish	Medium	Greenish	Fleshy	Very Juicy	Less sweet	Medium	50.0	15.1	30.2
CG-134	Obloid	Green yellow	Pink	Medium	Pink red	Crispy	Juicy	Less sweet	Low	109.0	36.5	33.5
CG-135	Semi-pyriform	Green	Pink	Medium	Pink	Fibrous	Medium	Medium sweet	Medium	130.0	33.8	26.0
CG-143	Obloid	Green yellow	Light pink	Strong	Pink	Crispy	Medium	Less sweet	Low	74.0	26.8	36.2
CG-144	Oblique	Green yellow	Light pink	Medium	Light pink	Crispy	Medium	Less sweet	Medium	98.0	20.3	20.7
CG-151	Semiobloid	Green yellow	Light pink	Weak	Light red	Fleshy	Very Juicy	Sweet	Low	92.0	39.7	43.2
CG-171	Semi-pyriform	Light yellow	Light pink	Strong	Light red	Crispy	Very Juicy	Less sweet	Medium	147.0	45.6	31.0
CG-173	Pyriform	Light yellow	Light pink	Weak	Light red	Crispy	Very Juicy	Medium sweet	Low	148.0	50.1	33.9
CG-182	Spheroid	Light yellow	Light pink	Medium	Red	Crispy	Medium	Less sweet	Medium	116.0	57.7	49.7
CG-183	Spheroid	Green yellow	Light pink	Medium	Red	Crispy	Juicy	Medium sweet	High	96.0	39.7	41.4
CG-185	Pyriform	Light yellow	White	Weak	Greenish	Fleshy	Very Juicy	Sweet	Low	71.0	13.5	19.0
BB-1	Globose	Light yellow	Light pink	Weak	Light pink	Fleshy	Very Juicy	Sweet	Low	95.0	34.4	36.2
Mean	-	-	-	-	-	-	-	-	-	91.6	33.46	37.58
CV%	-	-	-	-	-	-	-	-	-	12.7	12.5	9.8
LSD0.05	-	-	-	-	-	-	-	-	-	21.4	10.5	11.2

Means followed by same letter(s) in the same column do not differ significantly at 5% level by LSD.

Albedo colour in most of the genotypes was light pink followed by white, pink and greenish. Regarding adherence of albedo to pulp, the fruits in which albedo adhered weakly with the pulp is preferred to the consumers for easy peeling. It is noted that fruits of the most of the genotypes had medium adherence of albedo to pulp. A weak adherence of albedo to pulp was observed in CG-1, CG-12, CG-151, CG-173, Cg-185 and the check. Shanmugavelu (1987) stated about similar findings. Pulp colour is an important factor for the consumers. It is assumed that coloured pulp contains more carotene than greenish. Pulp colour in the genotypes varied. Among them, 25% genotypes were light red, 20% light pink and pink, 15% red and greenish and 5% pink red in colour. The result obtained in the study was in agreement with Ullah et. al., (2001), Azmatullah (1987), Hossain (1983), Shanmugavelu (1987), Singh (1995), Zeng (1999), Chen and Rao (1999), Chen and Lin (1998). They stated varied pulp colour in pummelo. Pulp texture in most of the genotypes was fleshy but some were either crispy or fibrous.

Regarding juiciness, it is revealed from the table that majority of the genotypes were very juicy. Variety with very juicy nature is liked by the consumers. Among the genotypes, 65% were very juicy, 20% were medium juicy and 15% were juicy. Ullah et al., (2001) also categorized the studied pummelo cultivars as less juicy, medium juicy and very juicy; and they noted variation among the cultivars. Data regarding taste in the genotypes were recorded as sweet, medium sweet and less sweet. It is observed that 35% genotype was sweet, 35% medium sweet and 30% less sweet. Very sweet pulp in the pummelo variety BARI Batabi lebu-4 was stated by Rahman et al., (2005); while, in another study, 13.0, 83.0 and 4.0% cultivars were less, medium and very juicy, respectively (Anon, 1998). Like other characters, bitterness in the studied genotypes also varied. Maximum genotypes (70%) had bitterness low or nil, medium in 25% genotypes and high in CG-183. Ullah et al., (2001) reported similar variable results regarding bitterness in the studied pummelo cultivars.

Data on seed characters in Table 4 revealed that a wide range of variation in case of number of seeds per fruit. It varied from 23 (CG-18) to 148 (CG-173). Thirteen genotypes produced seeds below or closer to the check (95.0). Some authors reported differences in number of seeds per fruit. Xie (1998) found 3-5 seeds/fruit, Bose et al., (2001) stated about 40-45

seeds/fruit, Azmatullah et al., (1987) reported 89-110 seeds/fruit, Ullah et al., (2001) obtained 57-153 seeds/fruit; while Hossain (1983) reported about 0-94 seeds/fruit. Webber and Batchelor (1948) also observed nearly seedless pummelo variety. Weight of seeds per fruit varied from 9.8g (CG-18) to 57.7g (CG-182). Weight of 100 seeds was minimum (19.0g) in CG-185 and maximum (49.7g) in CG-182 (Table 4). It implies that CG-185 and CG-182 produced smaller and large sized seeds, respectively compared to other genotypes.

Conclusion

It is revealed from the study of 20 pummelo genotypes that CG-5, CG-12, CG-18, CG-151 and CG-185 were superior to rest of the genotypes including the check. These genotypes may be selected for further evaluation to develop variety(ies). Moreover, hybridization programme may be undertaken to develop high yielding, high carotene content variety with the least or no bitterness.

References

Anonymous. 1998. BARI Annual Report 1997-1998. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur-1701.

Anonymous. 1999. BARI Annual Report 1998-1999. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur-1701.

Anonymous. 2001. BARI Annual Report 2000-2001. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur-1701.

Anonymous. 2002. BARI Annual Report 2001-2002. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur-1701.

Anonymous. 2003. Research Report 2002-2003. Citrus Research Station, Bangladesh Agricultural Research Institute, Jaintapur, Sylhet.

Anonymous. 2009. Krishi Projukti Hatboi (Handbook on Agro-technology), 3rd edition (reprint). Sattar, M.A., M.M. Rahman, M.H. Rashid, M.S.Ali and M.S.Alam (eds.). Bangladesh Agricultural Research Institute, Joydebpur, Gazipur-1701. p:560.

Azmatullah, M. 1987. Studies on the physio-morphological characteristics of different pummelo varieties. An Unpublished M. Sc. Thesis. Department of Horticulture, Institute of Post Graduate Studies In Agriculture, Salna, Gazipur.

Azmatullah, M., A.M. Abdullah and M.A. Hoque. 1987. Studies on the

physio-morphological characteristics of ten pummelo cultivars. Bangladesh Hort. 15(2):11-16.

Azmatullah, M., M.A. Rahman and M.A.I. Khan. 2005. Evaluation of some superior local genotypes of pummelo. Research Report on Fruit Improvement 2004-05. Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Moulvibazar. pp:21-22.

Bose, T. K., S.K. Mitra and D. Sanyal. 2001. Fruits: Tropical and Sub-tropical. Vol. 1. Naya Udyog, 206 Bidhan Sarani, Calcutta, India.

Cai, X.Y. 1995. Hongzai Tianyou, a promising pummelo cultivar. China Citrus. 24(4): 35.

Chen, J.W. and Y.F. Lin. 1998 Effect of Xinye plant nutrient liquid on the growth and production of Yuhuanyou pummelo variety. South China Fruits. 27(3): 27-28.

Chen, W. and J. Rao. 1999. Gusangyou, a good local pomello variety. South China Fruits. 28(4): 18.

Dhillon, B.S. and Z. Singh. 1993. Fruit growth and development in citrus. In: Advances in Horticulture. Volume 3. Fruit Crops. Part-3. K.L. Chadha and O.P. Pareek [eds.]. Malhotra Publishing House, New Delhi-110064, India. pp: 1167-1183.

Frost, H. B. and R. K. Soost. 1968. Seed Reproduction: Development of Gametes and Embroids. In: The Cirtus Industry. Volume II. Reuther, W., H. J. Webber and L. D. Batchelor (eds.). Division of Agril. Sci., University of California, USA. pp: 290-324.

Hodgson, R.W. 1967. Horticultural Varieties of Citrus. In: The Citrus Industry. Volume I. Reuther, W., H. J. Webber and L. D. Batchelor (eds.). Division of Agril. Sci., University of California, USA. pp:431-591.

Hossain, M.M. 1983. Morphological studies of different citrus plants, An Unpublished Thesis. Department of Horticulture, Bangladesh Agricultural University, Mymensingh.

IPGRI. 1999. Descriptors for Citrus. International Plant Genetic Resources Institute, Rome, Italy. p:1-66.

Janick, J. and J.N. Moore. 1996. Fruit Breeding (Volume I): Tree and Tropical Fruits. [Eds.]. John Wiley & Sons, Inc. New York.

Li. T. 1997. Rongxian Hongxinyou. South China Fruits. 26(5): 18.

Long, Y.Y. 2000. "Longyan Hongyou", a sport of Guanximiyou pummelo variety. South China Fruits. 29(2): 6.

Mondal, M.F and M.R.Amin. 1990. Pholer Bagan. (In Bengali). Mrs. Afia Mondal, Bangladesh Agricultural University Campus, Mymensingh.

Morton, J. 2006. Pummelo. In: Fruits of warm climates. Morton, J.F and F.L. Miami (eds). P. 147-151. [Collected from browsing web site- http://www.hort.purdue.edu/newcro p/ morton/ index.html].

Purseglove, J.W. 1987. Tropical Crops-Dicotyledons. Longman Scientific and Technical Co. Ltd., London. p:719

Rahman, M.A. and M.A.I. Khan. 2003. Evaluation of some superior local genotypes of pummelo. Research Report on Fruit Improvement 2002-03. Regional Agril. Res. Station, Bangladesh Agricultural Research Institute, Moulvibazar. pp: 13-15.

Rahman, M.M., M.A. Quayum, M.S. Alam and M.L.Rahman. 2005. Udbhabito Krishi Projukti 2003-2004. (In Bengali). [Developed Agro-technology 2003-04]. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur-1701. pp: 34-36.

Randhawa, G.S. and K. C. Srivastava. 1986. Citriculture in India. Hindustan Publishing Corporation (India), Delhi-110007. p: 501.

Rashid, M.M., M.A. Quadir and M.M. Hossain. 1987. Bangladesher Phol (in Bengali). Rashid Publishing House, Bangladesh Agricultural Research Institute Campus, Joydebpur, Gazipur. pp-253.

Saha, M.G. 2005. Batabi lebu. In: Foler Adhunik Utpadon Projukti (Modern Technology of Fruit Production). Bari, M.A., M.N. Uddin, M. Bishwash, M.A. Haque, M.A.J. Bhuyian and M.M. Rahman (eds.). Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. pp:42-45.

Shanmugavelu, K.G. 1987. Citrus. In: Production technology of fruit crops. SBA Publications, 1/1 Meredith Street, Calcutta-700072, India. pp: 264-294.

Singh, A. 1995. Citrus. In: Fruit Physiology and Production. Kalyani Publishers, New Delhi-110002, India. pp: 298-327.

Ullah, M.A., M.A. Mannan, M.S. Islam, M.A. Kashem and K.M. Nasiruddin. 2001. Evaluation of fruit characteristics and yield of some

local pummelo germplasms. Bangladesh J. Crop Sci. 12(1&2): 115-121.

Webber, H.J. and L.D. Batchelor. 1948. The Citrus Industry. University of California Press. Berkely and Los Angels, USA. pp: 394-707.

Zeng, H. T. 1999. The performance of Yuhuanyou pomelo variety in Fujian province. South China Fruits. 28(5): 22.