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Morphological and physicochemical characterization of Burmese grape (*Baccaurea ramiflora* Lour.)

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ABSTRACT

Burmese grape (*Baccaurea ramiflora* Lour.) is a popular minor fruit in Bangladesh. Morphological and physicochemical characterization of Burmese grape was conducted at Pirujali, Gazipur during 2017-18 in eighteen Burmese grape genotypes. Wide variation was observed in case of growth, yield contributing characters, yield and fruit quality of the germplasm studied. Correlation study among different growth parameters of the genotypes was done to know the relationships so that superior genotypes can be selected for further experiment. Fruit set (%) was the highest in BS09 (77.27%) genotype and the lowest was in BS02 and BS03 and it was 36.84%. Zero percent fruit drop was observed in BS06, BS07 and BS17 and the highest fruit drop was in BS08 (50%) genotypes. The days to fruit maturity was the lowest (100 d) in BS12 genotype followed by BS13 (103 d) and the highest maturity days was in BS18 (132 d). For most of the desirable attributes BS02 showed better response such as maximum leaf length (28.31 cm), leaf breadth (9.02 cm), fruit length (34.1 mm), fruit diameter (33.9 mm), juice content (38 mL 20 seeds^{-1}), total soluble solids (18%), and ascorbic acid (13.2 mg 100g^{-1}). BS03 ranked the second among the genotypes on the basis of these parameters. Fruit number had negative correlation with fruit length, single fruit weight and juice content.

Keywords: Burmese grape, physicochemical, fruit quality, correlation

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1 Introduction

Burmese grape (*Baccaurea ramiflora* Lour.) is an underutilized fruit crop belonging to family Euphorbiaceae. The generic name is derived from Latin 'baccaurea' referring to the golden-yellow color of the fruits (Fig. 1) (Chakrabarty and Gangopadhyay, 1997). It is native to South-east Asian region. In Nepal, India, Myanmar, Bangladesh, South China, Indo-China, Thailand and Malaysia, this fruit is grown as wild as well as under cultivation (Bhowmick, 2011). It is grown mainly in the forest and homestead garden in Narsingdi, Sylhet, Gazipur, Netrokona and Kishoregonj districts of Bangladesh. Recent year, Bangladesh export few amount of this minor fruit from Narsingdhi (Hoque et al., 2017). Locally the fruit is known as 'Latkan' and it is a mild acidic fruit and mainly used as fresh fruit consumption (Khan, 2008). Aril is the

edible portion of the fruit and the number of aril per fruit is mainly 3-4. This edible portion is covered by leathery rind, fruits found in bunch and the bearing habit is cauliflory (Bhowmick, 2011). Simple leaf is arranged alternately, leaf has petiole and shape of the leaf is ovate to ovate-lanceolate. Mild bienniality cropping pattern is seen in this fruit tree (Pal et al., 2008; Hoang et al., 2008). Protein, fat (negligible), carbohydrate, ash; minerals- calcium, phosphorus, potassium, sodium and vitamins are found in Burmese grape. It also contains highest amount of iron (Haque et al., 2009). Fruits contain 5.5% protein, 178 mg vitamin C $100g^{-1}$ of pulp and among the minerals, the fruit contains 169 mg calcium, 137 mg potassium, 177 mg phosphorous, and 100 mg iron $100g^{-1}$ of fruit pulp (Kermasha et al., 1987).

It is known as novel food additives due to its high vitamin C, protein and iron content (Goyal et al., 2013). It is utilized as an antiphlogistic and anodyne against rheumatoid arthritis, cellulitis, abscesses and to treat injuries (Lin et al., 2003). Northern Thailand's hill-tribes use this plant as medicine (Yang et al., 2007). Young leaves are also used as vegetable, flavoring agent with curries and minced meat in Bangladesh (Hasan et al., 2009). Fresh bark is chewed or juice is used orally to cure constipation (Khan, 2008). Fruit juice is used for making wine. Local peoples use this fruit for ritual purpose during Holy Chariot Procession of Lord Jagannath (Goyal et al., 2013). Seeds of Burmese grape produce valuable annatto dye (Abdullah et al., 2005). For this reason it is grown in Bangladesh for fresh consumption as well as dye production and the percentage of annatto dye content is 4.8 – 6. Annatto dye is used for coloring silk, cotton and other textile materials. As it is a dioecious plant seed propagation is not favorable. Now propagation is done by stem cutting (Abdullah et al., 2005). Due to climate and soil type mutation and segregation is always conducted which is responsible for variability among different genotypes. For this reason seed propagation is not favourable.

Burmese grape is very popular fruit in Bangladesh but few experiment was conducted on Burmese grape in Bangladesh to improve this fruit. With this end in view, the present study was, therefore carried out to know the variability of existing Burmese grape and to evaluate the physical and biochemical features of different Burmese grape genotypes.

2 Materials and Methods

2.1 Experimental site and duration

The study was conducted at the Piruzali village of Gazipur district during March to September 2018. The study was located at the center of Madhupur Tract at 8.5 m above sea level. The site was previously under Sal forest and developed for residential area.

Figure 1. A Burmese grape (*Baccaurea ramiflora* Lour.) tree with fruits

2.2 Plant and inflorescence selection

The present experiment was carried out with eighteen genotypes of Burmese grape germplasm. All the plant aged about twenty five years and free from pest and diseases. After initiation of flower, eighteen plants, each from a genotype, were randomly selected from different part of that village. Five inflorescence bunches were tagged randomly from each selected plant.

2.3 Morphological data collection

Leaf length Ten leaves were collected from each plant randomly and leaf length was measured by using meter scale. Average leaf length was calculated by dividing total leaf length with total number of leaves.

Leaf breadth Leaf breadth was measured at the middle portion of the leaf by using meter scale. Average leaf breadth was calculated by dividing total leaf breadth with total number of leaves.

Number of flower and fruit per inflorescence After initiation of inflorescence, numbers of flowers were counted from each inflorescence. Numbers of fruits were counted after fruit setting and at maturity from each inflorescence.

Percent fruit set per plant Percent fruit set was calculated by the following formula:

Table 1. Leaf, flower and fruit characters of Burmese grape

Geno-type	Leaf L. (cm)	Leaf B. (cm)	Flower no. inflor.$^{-1}$	Fruit no. at setting	Fruit no. at matu.	Fruit set (%)	Fruit drop (%)
BS01	24.92b	8.59b	18 cd	8def	6 b	44.44ef	25bcdef
BS02	28.31a	9.02a	19 bcd	7f	6 b	36.84ef	14.29cdef
BS03	22.3d	8.2bc	19bcd	7f	6 b	36.84ef	14.29cdef
BS04	21.52efg	6.93fg	19bcd	10cdef	0.375	52.63cdef	10def
BS05	20.09h	7.27ef	22ab	15ab	0.46	68.18abc	26.67bcdef
BS06	17.43j	6.12ij	20 abc	9def	0.375	45ef	0f
BS07	21fg	7.61de	21 abc	11cde	0.46	52.38cdef	0f
BS08	23.85c	8.1c	23a	12bcd	6 b	52.17cdef	50a
BS09	21.93de	7.79cd	22ab	17a	0.46	77.27a	35.29abc
BS10	19.62h	6.5hi	19bcd	9def	6 b	47.37ef	33.33abc
BS11	21.72def	6.92fg	16d	9def	5 b	56.25bcde	44.44ab
BS12	17.32j	5.86j	19bcd	8ef	5 b	42.11ef	37.5abc
BS13	19.55h	6.51h	18cd	13bc	0.375	72.22ab	30.77abcd
BS14	20.14h	6.49hi	18cd	9def	6 b	50def	33.33abc
BS15	19.45h	6.62gh	18cd	8ef	6 b	44.44ef	25bcdef
BS16	19.79h	7.31e	18cd	8ef	6 b	44.44ef	25bcdef
BS17	18.2i	6.61gh	20abc	10cdef	0.42	50def	0f
BS18	20.95g	6.87gh	19bcd	13bc	0.42	68.42abcd	23.08bcdef
CV (%)	2.08	3.2	9.84	20.24	20.42	21.5	65.08
LSD	0.72	0.38	3.15	3.43	2.65	18.8	24.9

Table 1. Continued

	Maturity (d)	Fruit L (mm)	Fruit D (mm)	Fruit wt. (g)	Peel wt. (g)	Peel thick-ness (mm)
BS01	122d	30ef	34.2a	16.25cd	6.6bc	3.2cd
BS02	116ef	33.9ab	34.1a	15.65d	8.63a	3.95a
BS03	115ef	34.7a	34.45a	17.55ab	8.45a	3.75b
BS04	124cd	32.7c	34.4a	17.65a	6.52bc	3.05def
BS05	130ab	28.4gh	29.4de	11.3ij	4.77gh	3efg
BS06	125cd	27.8hi	29.4de	10.66jk	3.99i	2.65h
BS07	113fg	28.5gh	31.1c	12.18gh	5.38efg	3.1de
BS08	110g	33bc	32.9b	16.32cd	7.04b	3.75b
BS09	125cd	27.7hi	28.5e	8.97l	4.24hi	3efg
BS10	117e	31.4d	31.9bc	14.11e	5.88de	3.8ab
BS11	116ef	28.5gh	28.8de	11.2ij	3.87ij	2.9fg
BS12	100h	29.7f	29.85d	11.90hi	4.02i	3.3c
BS13	103h	31.4d	32.9b	16.06cd	6.29cd	2.9fg
BS14	127bc	31de	31.5c	12.88fg	5.43ef	3efg
BS15	129ab	29.5fg	28.5e	10.99hij	5.10fg	2.85g
BS16	122d	33.5bc	34.2a	16.73bc	6.95b	3.65b
BS17	111g	29.2fg	31.4c	13.20f	5.46ef	3.7b
BS18	132a	27gi	26.8f	10.125k	3.37j	2.65h
CV (%)	1.9	2.23	2.28	3.69	6.87	3.24
LSD	3.74	1.12	1.18	0.82	0.64	0.17

L = length, B = breadth, no. =number, inflor = inflorescence, wt. = weight, and matu = maturity; Maturity indicates days to fruit maturity from fruit set; Values of a parameter with similar letter are not statistically different at P = 0.05; CV = co-efficient of variation, and LSD = least significant difference at 5% level of probability

$$FS\ (\%) = \frac{Fr_s}{Fl} \times 100 \quad (1)$$

Percent fruit drop Percent fruit drop was calculated by the following formula:

$$FD\ (\%) = \frac{Fr_s - Fr_m}{Fr_s} \times 100 \quad (2)$$

where, $FS(\%)$ = percent fruit set, $FD(\%)$ = percent fruit drop, Fr_s = number of fruit set after flowering, Fr_m = number of fruit mature, and Fl = number of flowers

Fruit size and fruit weight Ten fruits were taken for measuring fruit length, fruit diameter and fruit weight. Fruit length and diameter were measured by using slide calipers and weight was measured by using electrical balance. Averages of these parameters were calculated by dividing total of each parameter with total number of fruits.

Peel thickness and peel weight Peels were separated from ten fruit and peel thickness was measured by using slide calipers. Peel weight was measured by using electrical balance and averages of these parameters were done.

Single seed weight After separating seed from the rind of the fruit, single seed weight with flesh and single seed weight after removing flesh were measured by using electrical balance. Ten seeds were taken and averages of these parameters were calculated.

2.4 Chemical analyses

Juice was extracted by squeezing 20 seeds and amount of juice was measured by measuring cylinder. Then average juice content was calculated.

Total soluble solid and pH Total soluble solids (TSS % brix) contents of Burmese grape fruit pulp were estimated by hand refractometer (Model: Atago N1, Japan). A drop of Burmese grape juice squeezed from the fruit was placed on the prism of the refractometer and the soluble solid contents were recorded as percent Brix (at room temperature) and pH was measured by pH meter after diluting extracting juice from the fruits.

Ascorbic acid The ascorbic acid content was determined as per the procedure prescribed by Pleshkov (1976). Twenty (20) g fruit sample was taken in a warring blender. The sample was homogenized with warring blender by adding by adding 50 mL distilled water. The homogenized solution was transferred into a 100 mL volumetric flask and made it up to the mark with distilled water and then centrifuged. The supernatant liquid was again collected in the 100 mL volumetric flask. This was the extract solution for the determination of ascorbic acid. The ascorbic acid content was determined as per the procedure described by Pleshkov (1976). For estimating free ascorbic acid 10 mL of prepared extract was taken in conical flask. Five mL 5% KI, 2 mL of 2% starch solution, 2 mL glacial acetic acid was added to the extract. Finally it was titrated with 0.001N KIO_3 solution. Free ascorbic acid was quantified by using the following formula:

$$AAC = \frac{T \times F \times V}{V \times W} \times 100 \quad (3)$$

where, AAC = ascorbic acid content (mg $100g^{-1}$), T = titrated volume of KIO_3 (mL), F = 0.088 mg of ascorbic acid per ml of 0.001N KIO_3, V = total volume of sample extracted (mL), V = volume of the extract (mL) taken for titration, and W = weight of the sample taken (g).

Reducing sugar Amount of sugar determined by the Somogyi (1952) prescribed method. 10 mL of each of Bertrand A (40 g $CuSO_4.5H_2O$ dissolved in water and diluted to 1 L) and Bertrand (200 g sodium-potassium triturate and 150 g of NaOH dissolved in water and diluted to 1 L) solutions were added to 5 mL of sample solution. The conical flask was placed in hot plate (sand bath) and boiled for 30 min and kept overnight for cooling. The supernatant was decanted and discarded very carefully by keeping precipitation. The precipitation was washed repeatedly until blue color was present. Then, 10 mL of Betrand C [50 g $Fe_2(SO_4)_3$ and 115 mL conc. H_2SO_4 was added and diluted to 1 L] was added to dissolve the precipitation (Cu_2O). Finally the solution was titrated with 0.4% $KMnO_4$ solution. This was repeated thrice and reducing sugar (mg g^{-1}) was calculated. Reducing sugar was calculated comparing tabulated values. Before calculation of reducing sugar, factor of 0.4% $KMnO_4$ was determined.

Total sugar 5 mL of the extract solution was taken in a 100 mL conical flask and 2-3 drops of 4N KCl was added to it. Then the flask was boiled for three minutes on a hot plate for hydrolysis. After cooling the extract was neutralized with 1N NaOH to remove HCl and made up to the mark with water. Then 10 mL of the neutralized extract was taken into a 50 mL conical flask and 10 mL of both Betrand A and Betrand B solution were added, rest of the procedure was same as mentioned in reducing sugar.

Non reducing sugar The non-reducing sugar was calculated by deduction of reducing sugar from total sugar.

Table 2. Characters of seed and juice content of different Burmese grape genotypes

Genotypes	No. of seed fruit^{-1}	Weight of single seed with flesh (g)	Single seed weight (g)	Juice content (mL 20 seeds^{-1})
BS01	3 b	2.863 ab	0.4269 ab	35 bc
BS02	3 b	2.46 cde	0.3574 bcde	38 a
BS03	3 b	2.897 a	0.4273 a	37 ab
BS04	3 b	2.21 defg	0.313 efgh	35 bc
BS05	3 b	2 fghi	0.289 ghi	25 f
BS06	3 b	2.09 fgh	0.3229 defg	25 f
BS07	4 a	1.691 ij	0.2575 i	21 g
BS08	3 b	2.637 abc	0.367 bcd	32 d
BS09	4 a	1.565 j	0.3337 cdefg	20 g
BS10	3 b	2.526 bcd	0.312 efgh	29 e
BS11	3 b	2.16 efg	0.3136 efgh	27 ef
BS12	3 b	2.456 cde	0.333 cdefg	25 f
BS13	4 a	2.687 abc	0.3764 bc	35 bc
BS14	3 b	2.583 abc	0.366 bcd	33 cd
BS15	3 b	1.752 hij	0.2991 fghi	25 f
BS16	4 a	2.341 cdef	0.3457 cdef	36 ab
BS17	4 a	2.159 ghij	0.349 cde	26.5 f
BS18	3 b	1.876 cde	0.2745 hi	22 g
CV (%)	0	9.28	8.67	4.78
LSD	0	0.3493	0.0481	2.3173

Values of a parameter with similar letter are not statistically different at P = 0.05;
CV = co-efficient of variation, and LSD = least significant difference at 5% level of probability

Table 3. Fruit quality characters of different Burmese grape genotypes

Genotypes	TSS %	pH	Ascorbic acid (mg 100g^{-1})	Reducing sugar (g 100g^{-1})	Non-reducing sugar (g 100g^{-1})	Total sugar (g 100g^{-1})
BS01	14.8 bc	3.47 cd	12.76 a	1.75 ef	1.2 de	2.95 g
BS02	18 a	2.92 i	13.2 a	1.8 def	1.25 cde	3.05 fg
BS03	15 bc	2.94 i	13.2 a	1.1 i	0.8 f	1.9 i
BS04	15.5 bc	3.38 fg	11.4 b	1.15 i	0.55 g	1.7 j
BS05	16 b	3.48 cd	11 bc	1.85 cde	1.4 bcd	3.25 cd
BS06	16 b	3.54 b	11.4 b	1.7 fg	1.4 bcd	3.1 ef
BS07	15 bc	3.46 cd	9.24 e	1.75 ef	1.4 bcd	3.1 ef
BS08	18 a	3.5 bc	13.21 a	1.9 cd	1.25 cde	3.15 def
BS09	15 bc	3.33 gh	11 bc	1.6 gh	1.55 ab	3.15 def
BS10	14.5 bc	3.32 h	9.13 e	2.05 ab	1.15 e	3.2 de
BS11	16 b	3.32 h	10.45 c	1.9 cd	1.25 de	3.15 def
BS12	14 c	3.31 h	9.32 de	2.05 ab	1.75 a	3.8 a
BS13	16 b	3.31 h	7.04 f	1.85 cde	1.3 cde	3.15 def
BS14	18 a	3.55 b	13.2 a	2.15 a	1.2 de	3.35 c
BS15	16 b	3.35 fgh	11 bc	1.95 bc	1.1 e	3.05 fg
BS16	18 a	3.81 a	11 bc	2.05 ab	1.45 bc	3.5 b
BS17	15.5 bc	3.44 de	10.17 cd	1.55 h	1.1 e	2.65 h
BS18	18 a	3.39 ef	13.2 a	1.85 cde	1.1 e	2.95 g
CV%	5.73	0.97	4.96	4.27	9.92	2.91
LSD (5%)	1.5237	0.0542	0.9173	0.12581	0.20204	0.14491

Values of a parameter with similar letter are not statistically different at P = 0.05;
CV = co-efficient of variation, and LSD = least significant difference at 5% level of probability

2.5 Statistical analysis

The data of various parameters recorded in the experiment were compiled and statistically analyzed through partitioning the total variance with the help of Statix-10 program. Correlation studies were done by using statistical package for the social science (SPSS) (Gomez and Gomez, 1984).

3 Results and Discussion

The data represented from the experiment revealed (Table 1) that different genotypes of Burmese grape varied among themselves regarding morphological characters of plant and physical attributes of fruits in fully ripe condition as well as the maturity days. The highest leaf length was observed in case of BS02 (28.31 cm) genotypes followed by BS01 (24.92 cm) and the lowest leaf length was in BS12 (17.32 cm) genotypes. Leaf breadth was highest in BS02 (9.02 cm) followed by BS01 (8.59 cm) genotypes and leaf breadth was least in BS12 (5.86 cm). Number of flower was highest in BS08 and it was 23 followed by BS05 and BS09 (22) genotypes. The lowest number of flower was in BS11 and it was 16. Number of fruit set was highest in BS09 and it was 17 and lowest in BS02 and BS03 genotypes and it was 7. The highest fruit number at maturity was observed in BS05, BS07 and BS09 genotypes and the fruit number was 11. The lowest fruit number at maturity was observed in BS11 and BS12 genotypes and the number was 5. Fruit set (%) was highest in BS09 (77.27%) genotypes and lowest was in BS02 and BS03 and it was 36.84%. Zero percent fruit drop was observed in BS06, BS07 and BS17 and the highest fruit drop was in BS08 (50%) genotypes. The lowest maturity days was observed in BS12 genotypes and it was 100 d followed by BS13 (103 d) and the highest maturity days was in BS18 (132 d).

Burmese grape can be harvested 80-85 d after fruit for the best desert quality was reported by Bhowmick et al. (2016). The highest fruit length was observed in BS03 (34.7 mm) followed by BS02 (33.9 mm) and the lowest fruit length was in BS18 (27 mm) genotypes. The highest fruit diameter was in BS03 (34.45 mm) genotypes and the lowest fruit diameter was in BS18 (26.8 mm) genotypes (Fig. 2). BS02. BS04, BS05, BS16 genotypes gave more or less same fruit length like BS03. Single fruit weight was highest in BS04 (17.65 g) and lowest was in BS09 (8.97 g). Peel weight and peel thickness was highest in BS02 and it was 8.63 g and 3.95 mm, respectively. The lowest peel weight and peel thickness was in BS18 and it was 3.37 g and 2.65 mm, respectively. An experiment conducted by Deb and Bhowmick (2013) on twelve accession of Burmese grape. In his experiment lowest maturity days was 78.33, the highest fruit length was 3.383 cm, the highest fruit diameter was 3.513 cm and the highest fruit weight was 19.93 g. The undesirable horticultural traits like lowest peel weight and peel thickness was 4.75 g and 1.99 mm. the highest fruit length 3.14 cm, fruit diameter 3.05 cm, fruit weight 18.41 g, peel weight 5.70 g was observed in 98 d Burmese grape by Pradhan et al. (2014). Gurung et al. (2018) conducted an experiment on Burmese grape and he found the highest fruit length 4.03 cm, fruit diameter 4.14 cm, fruit weight 15.42 g and peel weight 5.56 g.

The data represented from the experiment revealed (Table 2) that the number of seed per fruit was 4 in BS07, BS13, BS16 and BS17 and other genotypes gave same result and the number of seed was 3. Weight of single seed with flesh and single seed was highest in BS03 and it was 2.9 g and 0.43 g, respectively. The lowest single seed with flesh weight was in BS09 (1.57 g) followed by BS07 (1.69 g) genotypes. The lowest single seed weight was in BS07 and it was 0.26 g. The highest juice content of 20 seeds was observed in BS02 (38 mL) and the lowest in BS09 (20 mL) genotypes. Deb and Bhowmick (2013) reported that the highest weight of 10 single seed was 5.23 g and the highest juice content of 10 fruits was 74.10 mL. The highest seed weight (0.46 g) was found by Pradhan et al. (2014). The highest seed per fruit 3.22, 100-seed weight 51.68 g and juice content 50.42 mL 10 fruits^{-1} were observed by Gurung et al. (2018).

The data represented in Table 3 revealed that the highest TSS% (total soluble solid) was 18 and it was observed in BS02, BS08, BS14, BS16 and BS18. The lowest TSS% was in BS10 (14.5%) genotypes. The highest pH was in BS16 (3.81) and lowest was in BS02 (2.92). The highest ascorbic acid was found 13.2 mg/100g in BS02, BS03, BS08, BS14 and BS18 and lowest ascorbic acid was found in BS10 (9.13 mg 100g^{-1}). The highest reducing sugar was found in BS14 (21.5 mg g^{-1} or 2.15%), non-reducing sugar and total sugar was in BS12 and it was 17.5 (1.75%) and 38 (3.8%) mg g^{-1}, respectively. The lowest reducing sugar was found in BS03 (11 mg g^{-1} or 1.1%) followed by BS04 (11.5 mg g^{-1} or 1.15%). The lowest non-reducing sugar and total sugar was found in BS04 and it was 5.5 mg g^{-1} (0.5%) and 17 mg g^{-1} (1.7%), respectively. Deb and Bhowmick (2013) reported that highest TSS% and total sugar (%) was 13.12 and 4.29 among twelve accession of Burmese grape germplasms. Pradhan et al. (2014) recorded the highest ascorbic acid 23.01 mg 100g^{-1} and pH 6.09. Gurung et al. (2018) recorded the highest TSS 13.89%, total sugar 4.65% and reducing sugar 3.2%.

For most of the desirable attributes BS02 showed better response such as maximum leaf length (28.31 cm), leaf breadth (9.02 cm), fruit length (34.1 mm), fruit diameter (33.9 mm), Juice content (38 mL 20 seeds^{-1}), TSS% (18) and ascorbic acid (13.2 mg 100g^{-1}). BS03 also showed more or less similar result.

The correlation studies revealed (Table 4) that leaf length was highly significant to that of leaf breadth, peel weight, juice content and vitamin C content.

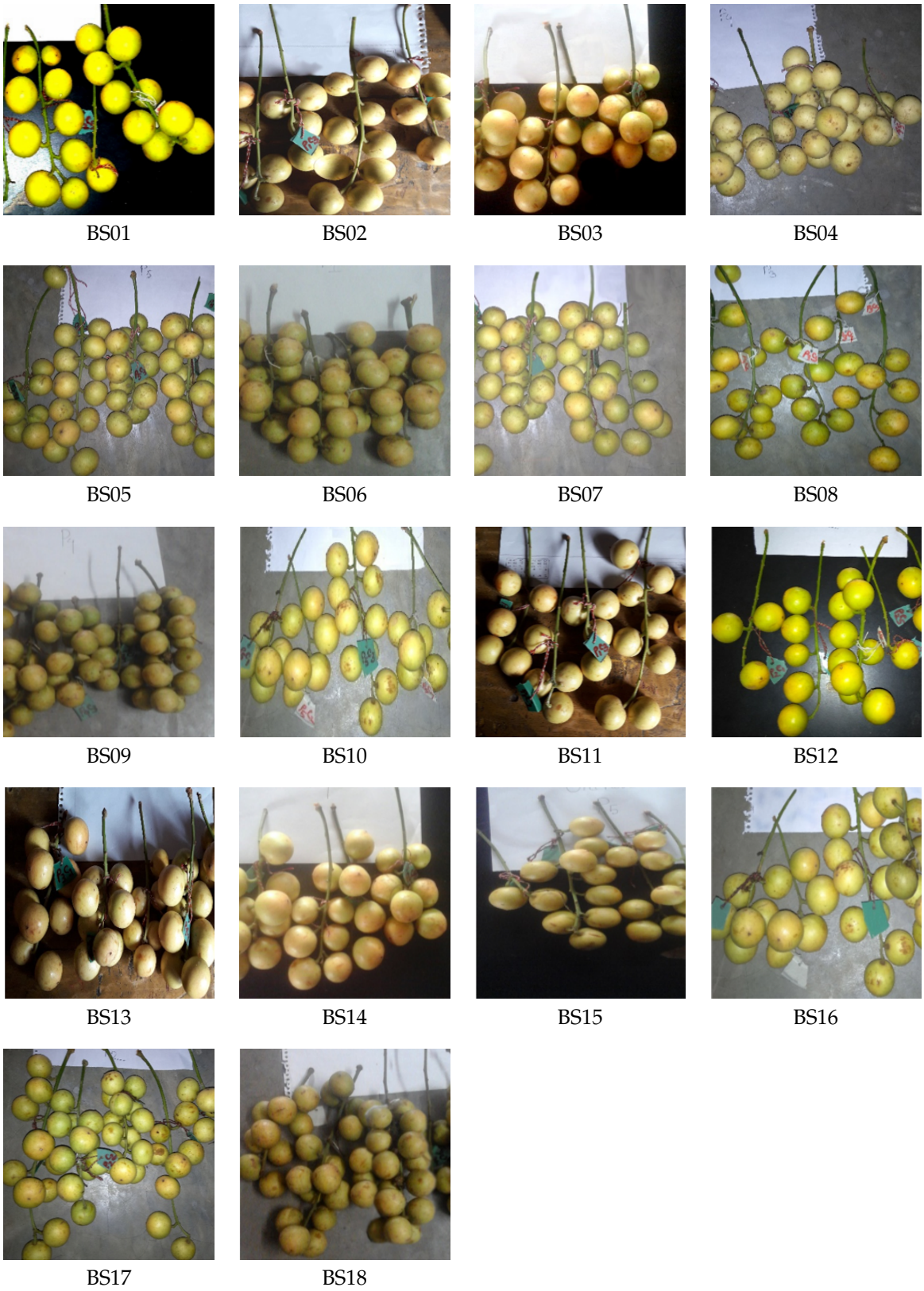

Figure 2. Photo of different germplasm (fruits) of Burmese grape

Table 4. Correlation studies among various growth and quality parameter in Burmese grapes

	LB	Flo	Fru	Mat	FL	FD	FW	PlWt	PlTh	Seed	SdWt	JC	TSS	pH	TS	VC
LL	0.913** 0	0.05 −0.842	−0.213 −0.396	0.06 −0.812	0.424 −0.08	0.438 −0.069	0.399 −0.101	0.609** −0.007	0.386 −0.114	−0.215 −0.288	0.265 −0.288	0.469* −0.05	0.318 −0.199	−0.463 −0.053	−0.23 −0.358	0.558* −0.016
LB		0.237 −0.344	−0.71 −0.78	0.064 −0.802	0.414 −0.088	0.481 −0.043	0.412 −0.089	0.660** −0.003	0.463 −0.053	0.013 −0.958	0.214 −0.393	0.4 −0.1	0.204 −0.417	−0.363 −0.138	0.257 −0.303	0.536* −0.022
Flo			0.553* −0.017	0.014 −0.957	−0.132 −0.602	−0.103 −0.683	−0.162 −0.52	−0.013 −0.96	0.147 −0.599	0.17 −0.499	−0.295 −0.235	−0.364 −0.137	−0.018 −0.943	0.1 −0.693	0.017 −0.947	0.106 −0.676
Fru				0.26 −0.297	−0.531* −0.023	−0.335 −0.174	−0.381 −0.119	−0.347 −0.159	−0.402 −0.098	0.492* −0.038	−0.625** −0.006	−0.533* −0.023	−0.11 −0.665	0.175 −0.488	−0.18 −0.474	−0.228 −0.363
Mat					−0.306 −0.216	−0.339 −0.169	−0.339 −0.169	−0.245 −0.326	−0.435 −0.071	−0.275 −0.269	−0.436 −0.07	−0.2 −0.426	0.322 −0.193	0.265 −0.288	−0.15 −0.554	0.509* −0.031
FL						0.868** 0	0.891** 0	0.915** 0	0.725** −0.001	−0.103 −0.685	0.690** −0.001	0.886** 0	0.238 −0.342	−0.302 −0.223	−0.333 −0.176	0.233 −0.352
FD							0.956** 0	0.904** 0	0.655** −0.003	0.071 −0.781	0.721** −0.001	0.885** 0	0.048 −0.849	0.137 −0.587	−0.384 −0.115	0.126 −0.619
FW								0.875** 0	0.603** −0.008	−0.026 −0.92	0.759** 0	0.906** 0	0.113 −0.655	−0.144 −0.568	−0.384 −0.115	0.138 −0.585
PlWt									0.740** 0	−0.001 −0.998	0.629** −0.005	0.898** 0	0.189 −0.452	−0.376 −0.125	−0.404 −0.097	0.283 −0.255
PlTh										0.055 −0.828	0.505* −0.033	0.521* −0.027	0.045 −0.858	−0.298 −0.23	−0.095 −0.708	0.148 −0.558
Seed											−0.3 −0.227	−0.167 −0.507	0.081 −0.749	0.285 −0.252	0.13 −0.608	0.531* −0.023
SdWt												0.817** 0	0.04 −0.876	−0.214 −0.394	−0.119 −0.637	0.175 −0.487
JC													0.292 −0.239	−0.215 −0.391	−0.323 −0.191	0.271 −0.276
TSS														0.222 −0.375	0.159 −0.53	0.522* −0.026
pH															0.392 −0.108	−0.121 −0.632
TS																−0.278 −0.263

LL = leaf length, LB = leaf breadth, Fru = number of fruit, Mat = maturity period, FL = fruit length, FD = fruit diameter, FW = fruit weight, PlWt = peel weight, PlTh = peel thickness, Seed = number of seed fruit^{-1}, SdWt = seed weight, JC = juice content, TSS = total soluble sugar, TS = total sugar content, VC = vitamin-C content;
* and ** designate significant at 1% and 5% level of significance, respectively; The top value in a cell is correlation vo-efficient, and the bottom value is p value.

Leaf length was negatively correlated with number of fruits, number of seed fruit^{-1}, pH and total sugar. Leaf breadth was highly significant with peel weight and vitamin C content and negatively correlated with number of fruits and pH and was positively correlated with other parameters. Number of flowers was highly significant with number of fruits and negatively correlated with fruit length, single fruit weight, peel weight, single seed weight, juice content and TSS% and it was positively correlated with other parameter. Number of fruits was negatively significant with fruit length, single seed weight and juice content. It was positively significant number of seed per fruit. Maturity period was positively significant with vitamin C content. Fruit length is positively significant with fruit diameter, single fruit weight, peel weight, peel thickness, single seed weight and juice content. Fruit diameter was positively significant with single fruit weight, peel weight, peel thickness, single seed weight and juice content. Single fruit weight was highly significant with peel weight, peel thickness, single seed weight and juice content. It was positively correlated. Peel weight was highly significant with peel thickness, single seed weight and juice content. Peel thickness was positively significant single seed weight and juice content. Number of seed per fruit was positively significant with vitamin C content. It was negatively correlated with single seed weight and juice content and positively correlated with other parameter. Single seed weight is highly significant with juice content and it was positively correlated. TSS% was positively significant with vitamin C content. The study thus revealed that fruit numbers have negative correlation with fruit length, single fruit weight and juice content. If fruit numbers increase, these parameters will decrease. Fruit length has strong positive correlation with fruit diameter, single fruit weight, peel weight, peel thickness, single seed weight and juice content. Single fruit weight has strong positive correlation with juice content. Bhowmick et al. (2016) reported that there was positive correlation between fruit weight and juice content. This indicate that selection should be made to increase juice content of fruit.

4 Conclusions

The present studies revealed that for most of the desirable attributes BS02 showed better result among different genotypes in terms of maximum leaf length, leaf breadth, fruit length, fruit diameter, Juice content, TSS% and ascorbic acid. BS03 also showed more or less similar result. So BS02 and BS03 genotypes can be studied further for confirming its superiority in multi-location. The correlation studies correlate different parameters of leaf and fruit.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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