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SEX PHENOLOGY OF BITTER GOURD (*Momordica charantia* L.) LANDRACES AND ITS RELATION TO YIELD POTENTIAL AND FRUIT QUALITY

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Small fruited bitter gourd (*Momordica charantia* L.) has fascinated the consumers for its medicinal value and deliciousness. Sex expression especially lower number of pistillate flowers than staminate flowers is the major limitation for yield improvements of this lucrative vegetable. An experiment was conducted to evaluate the physio-morphological characters, phonological behavior, fruit yield and quality of small fruited bitter gourd. The results revealed that small and round fruit bearing landrace produced shorter vine and more primary branches than oblong fruit bearing landrace. The oblong type produced larger leaf area and total dry matter that contributed main role of vine length and fruit yield. Small and round fruit bearing landrace produced greater number of pistillate flowers. On the other hand, all landraces produced the larger number of staminate flowers than pistillate flowers. The staminate flowers induced earlier in basal node whereas pistillate flowers initiated later in the proximal node. The fruit quality specifically fruit flesh weight of rind and weight of fruit flesh of different landraces were greatly varied. The total soluble solid (TSS) varied from 4.56 to 5.53 %, and ascorbic acid between 78.70 and 126.70 mg $100g^{-1}$, β-carotene and protein content varied from 95.50 to 106.50 µg 100^{-1}g and 1.58 to 2.24 mg $100g^{-1}$, respectively. Results concluded that frequency of primary branches and individual fruit weight greatly play dominant role to contribute yield, and the variations in fruit quality attributes leads to develop high yielding and quality bitter gourd through breeding techniques.
Keywords: Cucurbitaceae, bitter gourd, landrace, sex phenology, growth, yield

INTRODUCTION

The small fruited bitter gourd (*Momordica charantia* L.) belonging to Cucurbitaceae family is one of the most popular vegetables in Bangladesh and also in other Asian countries namely China, Taiwan, Vietnam, Thailand, India and the Philippines. It is adapted to a wide range of environments and can be grown in tropical and subtropical climates (Lim, 1998). It is more fascinated by the consumers due to its unique taste and high nutritional values. It is a different of nature's bountiful gifts to mankind, which is not only has fabulous digestion properties, it is a storehouse for remedies of many common ailment. The fruits, leaves and even the roots of *M. charantia* have been used in Ayurveda for a number of diseases such as a bitter stomachic, laxative and anthelmintic (Michael *et al.*, 2006; Ullah *et al.*, 2012). A compound known as 'charantin' present in the bitter gourd is used in the treatment of diabetes to reduce blood sugar level (Anunciado and Masangkay, 2002). The fruit accumulates bitterness with time due to build up of three pentacyclic triterpenes momordicin, momordicinin and momordicilin, and then loses the bitterness during ripening (Begum *et al.*, 1997; Lim, 2012). The fruit also has a rich amount of vitamin C, iron, phosphorus and carbohydrates (Behera, 2004). So, small type bitter gourd is considered as a high priced vegetable throughout the year for its medicinal value and unique taste.

Bitter gourd is a monoecious plant, naturally, inducing greater number of staminate flowers than the pistillate flowers. This flowering behavior is not advantageous and economical, because it results in lower fruit set and yield, which is a common problem in bitter gourd cultivation. To have the higher yield the staminate and pistillate flower ratio is needed to be synchronized (Ram *et al.*, 2000a). Androecy and gynoecy can usually be altered by environmental variables such as temperature, photoperiod and nutrition or by the application of plant growth regulators (Dhabolkar, 2006; Thomas, 2008). Landraces play an important role in breeding for developing high yielding and quality crop where fruit yield of the crop depends on the genetic potential of cultivars, (Dey *et al.*, 2007). The groundwork step in crop improvement programs is the collection and selection of desirable parents. While the adoption of a new cultivar by farmer is usually rapid because no additional cost is involved and existing cropping systems and soil/water management practices are generally not affected (Ladha *et al.*, 1988). Several researchers evaluated the bitter gourd landraces in various attributes across the diverse areas and create the opportunities for further development, and our attempts has been made for establishing relationship among the traits

(Kore *et al.*, 2003; Dey *et al.*, 2006). Therefore, the experiment was conducted to evaluate the sex phenology and performance of different physio-morphological attributes in relation to yield and nutritional status of small fruited bitter gourd landraces collected from different agro-ecological zones of Bangladesh.

MATERIALS AND METHODS

The experiment was conducted at the research field of the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh, and the soil of the experimental site was silty clay in texture having a pH of 5.5 to 6.0. It belongs to the Inseptisol with Shallow Red–Brown Terrace Soil (Brammer, 1978; Saheed, 1984). Locally collected 15 small fruited bitter gourd landraces namely BG-1, BG-2, BG-3, BG-4, BG-5, BG-6, BG-7, BG-8, BG-9, BG-10, BG-11, BG-12, BG-13, BG-14 and BG-15 were used in this experiment. The N, P, K, S and Zn fertilizers were applied in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively. The N was applied in splits at 15, 35 and 55 days after transplanting but remaining were applied during land preparation. The experiment was laid out in RCBD with three replications. The data on morphological parameters namely, number and lengths of primary branches were computed. Number of days to flowering was counted from the date of seed sowing to the date when the first pistillate flower bloomed. Number of nodes where first staminate flower bloomed of selected plants was recorded. Number of days from sowing to first flowering bud opening both for staminate and pistillate flower was recorded for every selected plant. Node order number where first pistillate flower bloomed was recorded for every selected plant. Number of fruits of each plant was counted after every harvest and the total number of fruits per plant was recorded, and the total weight and number of fruits from each plot was recorded in every harvest. Length of ten randomly selected fruits in each plot was measured after each harvest and the average was calculated. Fruit diameter of ten randomly selected fruits from each plot was determined by a digital slide calipers after each harvest and the average value was recorded. Ten randomly selected fruits were cut in the middle portion and thickness of the fruit flesh was measured by a digital slide calipers. The number of seeds per fruit was counted from randomly selected ten fruits harvested from every plant and the mean was used. Roots, shoots and leaves were separated from selected plants were dried in an electric oven for 72 hours at 70°C, and weighed by an electric balance. Harvest index (the ratio of economic yield to biological yield) was calculated according to Mia and Shamsuddin (2011). The biochemical and fruit quality attributes namely, leaf chlorophyll content, N concentration, β carotene, protein contents were computed following the standard methodologies (AOAC, 1980; Coombs *et al.*, 1985; Thomas *et al.*, 1967).

Collected data were analyzed statistically using the Statistical Analysis System (SAS, 2004). Following the analysis of variance procedure (ANOVA), differences among treatment means were determined using the Least Significant Difference (LSD) and Duncan's New Multiple Range Test (DMRT) comparison method (whenever applicable) at 5% level of significance ($P \leq 0.05$). Correlation analysis was performed for the estimation of relationships between different traits.

RESULTS

Primary branch and vine length**:** Number of primary branches was also influenced by different landraces with BG-8 produced the maximum number of branches per vine while the minimum was found in BG-12 (Table 1). The small and round fruit bearing landraces produced greater number of primary, secondary and tertiary branches. Similarly, bitter gourd landraces differed significantly; for vine length and the highest length of vine were recorded in BG-13 while the lowest was found in BG-2 (Table 1). Among the landraces there was a tendency of showing shorter vine in small and round fruit bearing landraces while larger vine length in oblong and large fruit producing landraces.

Leaf area and chlorophyll content**:** The leaf area was significantly influenced by landraces due to the inherent characters of the different landraces of bitter gourd (Table 1). The highest average leaf area was found in BG-13 and the smallest leaf area was noted in BG-14. The round and small fruit producing plant had small leaf area. On the other hand, large fruit bearing plant produced larger leaf area.

Total chlorophyll content in bitter gourd landraces varied from 1.68 to 1.88 mg g^{-1} at maximum flowering stage (Table 1). It is evident that the highest chlorophyll a and chlorophyll b were recorded in BG-5 while BG-6 produced lowest amount of chlorophyll at flowering stage.

Leaf N concentration**:** The N concentration of the fully expanded leaf of bitter gourd landraces did not vary significantly at flowering stage (Table 1). The results revealed that N concentration in leaves was the highest in the landrace BG-5 and BG-14, and it was the lowest in BG-10. It might be due to variation in mineral nutrient uptake efficiency of different landraces.

Sex phenology**:** The number of days required to first staminate flower opening ranged from 39 to 53 days and pistillate flower from 40 to 55 days (Table 2). The minimum number of days required to staminate and pistillate flowering was found in BG-14 and the maximum number of days required for staminate and pistillate flowering was observed in BG-15 and BG-13, respectively.

Table 1. Morpho-physiological characters and N concentration of small fruited bitter gourd landraces

Landraces	Length of vine (cm)	No. of primary branches plan^{-1}	Leaf area (cm^2)	Chlorophyll content (mg g^{-1})			Leaf N (%)
				Chl a	Chl b	Total	
BG-1	251.7 efg	7.50 fg	35.08 g	1.25a	0.45a	1.70a	1.39a
BG-2	235.0 g	9.26 bcd	42.40 e	1.24a	0.45a	1.69a	1.46a
BG-3	264.3 d-g	7.26 fg	37.25 f	1 .28a	0.45a	1.73a	1.41a
BG-4	291.7 cd	11.88 b	45.32 d	1.26a	0.46a	1.71a	1.45a
BG-5	331.7 ab	10.22 bc	38.42 f	1.40a	0.48a	1.88a	1.58a
BG-6	268.3 def	9.63 bcd	32.42 h	1.23a	0.45a	1.68a	1.43a
BG-7	255.0 efg	9.05 cde	41.75 e	1.28a	0.47a	1.74a	1.40a
BG-8	295.0 cd	12.53 a	35.00 g	1.31a	0.48a	1.79a	1.46a
BG-9	270.0 def	8.85 de	29.27 i	1.36a	0.42a	1.78a	1.56a
BG-10	255.0 efg	10.10 bc	28.75 i	1.29a	0.53a	1.82a	1.31a
BG-11	238.3 fg	7.66 f	45.81d	1.35a	0.46a	1.71a	1.43a
BG-12	318.3 bc	6.01 h	55.32 b	1.24a	0.44a	1.68a	1.32a
BG-13	351.7 a	6.51 gh	65.37 a	1.35a	0.44a	1.69a	1.47a
BG-14	279.0 de	8.09 ef	25.08 j	1.27a	0.46a	1.73a	1.58a
BG-15	310.7 bc	8.85 de	52.20 c	1.33a	0.44a	1.81a	1.48a

In a column values having common letter (s) do not differ significantly (P≤ 0.05) by DMRT

Table 2. Sex expressions in different genotypes of small fruited bitter gourd

Landrace	Days to flower		Node order for flowering		Flower plant^{-1}		Sex ratio (S/P)
	Staminate	Pistillate	Staminate	Pistillate	Staminate	Pistillate	
BG-1	42.33 d-f	48.67 b-f	11.17 b-d	16.67 abc	383.67 b	48.50 d	7.96 de
BG-2	47.33 a-f	49.00 b-f	10.50 cd	15.00 abc	285.37cd	57.08 c	5.02 g
BG-3	46.00 b-f	45.67 ef	11.67 a-d	17.00 abc	213.83 ef	48.17d	4.43 g
BG-4	42.00 e-g	47.00 def	10.83bcd	13.33 cd	343.32 bc	65.75 bef	5.23 fg
BG-5	42.83 d-g	52.33 a-d	10.33 cd	13.67bcd	314.79 c	28.67 cd	11.09 b
BG-6	44.23 c-g	53.33 abc	13.33 ab	15.00 abc	317.00 c	53.03 cd	6.01 fg
BG-7	50.00 abc	53.67 abc	14.00 a	16.67 abc	237.15def	26.87 e-g	8.88 cd
BG-8	47.83 a-e	50.17 a-e	12.70abc	16.00 abc	432.21 a	52.33 cd	8.25 de
BG-9	44.33 c-g	44.33 fg	9.67d	15.33 abc	433.05 a	31.93 e	13.67 a
BG-10	48.33 a-d	48.33 c-f	9.83d	17.33 ab	335.36 bc	58.58 c	5.72 fg
BG-11	41.40 fg	49.67 a-f	7.00 e	10.67 d	150.52 gh	21.83 g	6.91 ef
BG-12	51.33 ab	54.00 ab	14.33 a	18.00 a	188.75 fg	20.83 g	9.15 cd
BG-13	51.67 ab	54.67 a	14.33 a	18.67 a	125.28 h	13.17 h	9.50 bcd
BG-14	39.43 g	40.00 g	12.67abc	13.67 bcd	433.91a	73.50 a	5.96 fg
BG-15	53.33 a	53.33 abc	13.33 ab	18.00 a	250.48 de	24.08 fg	10.42 bc

Data followed by the same letter within a column do not differ significantly (P≤0.05) by DMRT

The lowest number of nodes both for staminate flowers (7.00) and pistillate flower (10.67) was found in BG-11 (Table 2). In general, it was observed that the staminate flowers appeared at 7 to 14 nodes and pistillate flowers at 7 to 18 nodes in different landraces. The differences in flower initiation early in lower nodes were due to genetic characters of the landraces.

The number of staminate and pistillate flowers plant^{-1} was influenced by different landraces and the highest number of pistillate flowers was produced by BG-14 while, the lowest number of pistillate flowers was found in BG-13 landraces. The greatest number of staminate flower was found in landrace BG-14. However, number of staminate flowers was the lowest in landraces BG-13 (Table 1). The lowest staminate and pistillate flower ratio was observed in BG-3. Higher pistillate flower producing landrace suppressed the staminate flowers consequently provided higher yield (Fig.1).

***Relationship between pistillate flowers and fruit yield*:** A negative linear relationship was found between the pistillate flowers and the fruit yield plant^{-1} (Fig. 1A). The negative linear relationship (Y= -0.05195x + 7.4199) between the pistillate flower and fruit yield was best explained for its value of co-efficient of determination (R^2= 0.26). It was observed that yield decreased with the increasing in pistillate flowers. It might be due to decrease of average individual

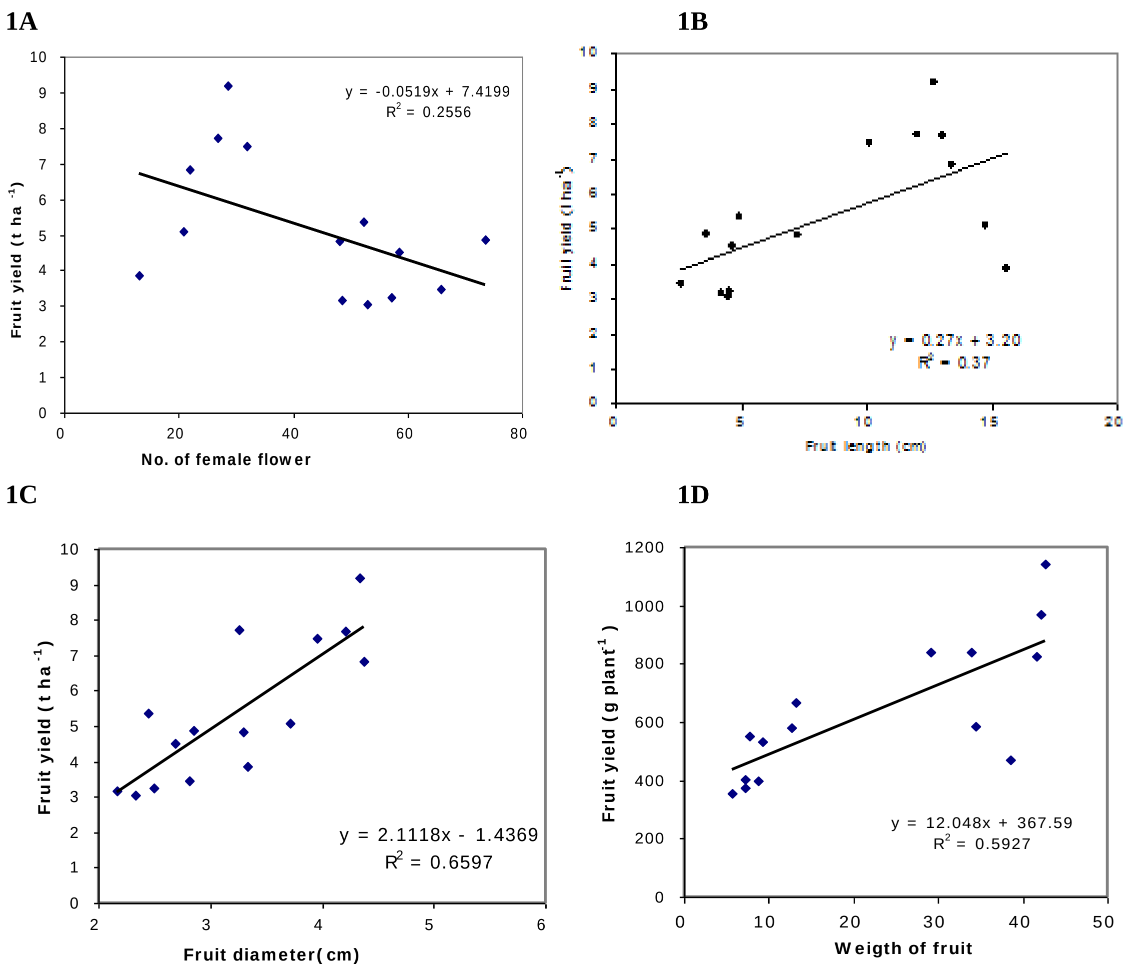

Figure 1. Relationship between fruit yield and fruit attributes; 1A: Fruit yield and number of pistillate flower, 1B: fruit yield and fruit length, 1C: fruit yield and fruit diameter, 1D: Fruit yield and fruit weight

fruit weight in greater number of fruit bearing landraces. Larger number of pistillate flowers produced greater number of fruits but it did not produce higher yield, because fruit yield is the direct contribution of individual fruit weight and number of branches plant^{-1}.

Yield attributes and fruit yield**:** The highest number of fruit per plant (71.57) was recorded in BG-14 (Table 3). It is apparent that the small and round fruit bearing landrace produced larger number of fruits per plant. It might be due to small fruit bearing landraces produced greater number of primary and secondary branches plant^{-1}. The fruit length varied widely from 3.53 to 15.60 cm and diameter from 2.16 to 4.38 cm (Table 3) where the landrace BG-13 recorded the highest fruit length (15.60 cm). Average weight of fruit^{-1} varied significantly due to the genotypic variation, and ranged from 5.65 to 42.57g where BG-5 produced heaviest fruit (Table 3). The results demonstrated that the average fruit weight directly contributed to fruit yield.

Fruit length is related to the fruit production and a positive linear relationship was found between fruit length and the fruit yield (Fig. 1B). It was observed that the equation $Y = 0.27x + 3.20$ is best fitted to the data, and the value of co-efficient of determination (R^2= 0.37) showed that the fitted regression line had a significant regression co-efficient. It was observed that with the increase in fruit length the yield plant^{-1} was also increased. There was a strong positive and linear relationship between fruit diameter and the fruit yield (R^2 = 0.6597) (Fig. 1C). It revealed that fruit yield increased significantly with the increase in fruit diameter. There was a significant positive linear relationship between fruit weight and fruit yield which indicated that fruit yield increased with the increase in average fruit weight of landraces (Fig. 1D). The value of co-efficient of determination (R^2=0.59) showed that the fitted regression lines had significant regression co efficient.

Total dry matter (TDM)**:** The TDM is the ultimate result of all physiological and biochemical activities of plant. The

Table 3. Fruit morphological attribute and fruit yield of bitter gourd land races

Landrace	No. of fruit (plant^{-1})	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight (g)	Fruit yield (g plant^{-1})	HI (%)
BG-1	45.95 f	4.16 hi	2.16 h	8.65 fg	397.5 h	14.19fg
BG-2	55.76 d	4.50 h	2.50 fg	7.24 h	403.7 h	13.75 g
BG-3	45.91 f	7.23 g	3.29 e	12.63 e	580.0 e	17.68 d
BG-4	62.65 b	4.54 h	2.81 f	5.65 i	354.2 i	15.63 e
BG-5	26.49 h	12.58 de	4.33ab	42.57a	1142.0 a	24.10 a
BG-6	51.90 e	4.46 h	2.33 gh	7.25 h	376.3 hi	13.71 g
BG-7	24.83 i	11.02 e	3.26 e	33.85 c	840.5 c	21.43 b
BG-8	50.81 e	4.86 h	2.45 fgh	13.10 e	665.6 d	16.69 de
BG-9	28.84 g	10.09 f	3.96 bc	29.12 d	839.8 c	23.65 a
BG-10	57.37 c	4.60 h	2.68 fg	9.30 f	533.8 f	19.94 c
BG-11	19.83 k	13.40 c	4.38 a	41.61 a	825.3 c	24.00 a
BG-12	17.08 i	14.74 b	3.72cd	34.36 c	586.9 e	20.52 bc
BG-13	12.15 m	15.60 a	3.33de	38.58 b	468.7 g	15.46 ef
BG-14	71.57 a	3.53 i	2.85 f	7.74 gh	553.9 ef	14.19 fg
BG-15	22.96 j	13.01cd	4.21ab	42.17 a	968.3 b	13.75 g

In a column values having common letter (s) do not differ significantly ($P \leq 0.05$) by DMRT

landrace BG-5 accumulated the highest amount of TDM, while BG-6 accumulated the least amount (216.20 g plant^{-1}) (Fig. 2).

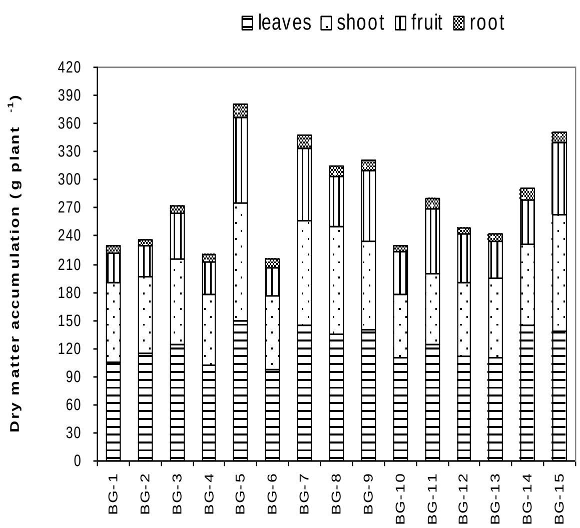

Figure 2. Dry matter partitioning into leaves, stem, roots and fruits of small fruited bitter gourd

Fruit yield**:** The fruit yield per plant varied from 354.2 to 1142.0 g, and the highest fruit yield was recorded in landrace BG-5 which was significantly different from all other landraces (Table 3). The lower fruit yield was produced by the small and round fruit size bearing landraces. The landrace BG-5 produced maximum fruit yield might be due to greater number of primary branches and larger fruit weight. The increases in number of primary branches plant^{-1} and average fruit weight plant^{-1} are the direct contributor to higher fruit yield. All bitter gourd landraces also showed significant variations in terms of harvest index (HI) ranging from 13.71 to 24.10 (Table 3). The highest HI value was recorded in landrace BG-5 and the lowest HI was observed in BG-6.

Fruit quality**:** Significant differences in rind thickness and weight were found among the landraces (Table 4). The highest rind thickness (0.61 cm) was recorded in landrace BG-5 and it was least (0.42 cm) in landrace BG-14 followed by landrace BG-1, respectively. Significant variation was seen for rind weight that varied from 10.15 to 37.99 g with maximum value was observed in landrace BG-13. The result clearly indicated that larger rind thickness was found in oblong fruit bearing landraces compared to small and round type landraces.

Maximum flesh thickness (2.30 cm) was found in BG-5, while it was least (1.29 cm) in landrace BG-14 (Table 4). The highest flesh weight was found in BG–11 (11.56 cm). Fruit flesh ranged from 1.29 to 2.30 cm. The flesh weight varied from 9.41 to11.56 g in BG-14 and BG-11, respectively.

Reduced seed content of fruits of is a desirable character, and significant differences in number of seeds per fruit bitter gourd was recorded (Table 4). The highest number of seed (26.04) was observed in landrace BG-12 followed by BG-11 (24.95) and both behaved statistically alike, while it was minimum in landrace BG-14. Generally the small size fruits contained less number of seeds.

Nutritional value**:** Considerable variation was observed in respect to different nutritional aspect in different bitter gourd landraces (Table 4). The highest TSS was found in BG-14 and it was the lowest in BG-15. The fruits of BG-14 contained the highest amount of ascorbic acid content

Table 4. Fruit quality characteristics of small fruited bitter gourd land races.

Land race	Thickness of rind (cm)	Thickness of fruit flesh (cm)	Weight of rind (g)	Weight of fruit flesh (g)	Number of seeds fruit^{-1}	Total soluble solids (%)	Protein (mg 100g^{-1})	Ascorbic acid (mg 100g^{-1})	Β-Carotene (µg 100g^{-1})
BG-1	0.43 f	1.62 ef	12.47 k	9.97 cd	18.39d	4.93	1.78 a-d	94.20 b-e	95.50
BG-2	0.45 ef	1.55 f	16.21 g	10.98abc	16.18 f	4.83	1.73 b-d	88.53 cde	98.88
BG-3	0.47 ef	1.60 ef	5.45 gh	10.06 cd	12.41 h	5.38	1.61 cd	84.42 cde	97.94
BG-4	0.46 ef	1.67 ef	13.65 j	10.16 cd	15.87 f	5.30	1.73 bcd	100.50 bc	101.30
BG-5	0.61 a	2.30 a	35.60 b	11.30 ab	23.55 b	4.63	2.24 a	85.10 cde	101.20
BG-6	0.49 cde	1.65 ef	14.26ij	10.16 cd	14.78 g	4.90	1.83 a-d	99.83 bcd	106.50
BG-7	0.49 de	1.92 d	16.28 g	9.85 cd	17.52de	4.68	1.93 a-d	80.40 e	100.50
BG-8	0.53 bcd	1.72 e	14.61 hi	9.46 d	17.71de	5.26	1.81 a-d	106.70 b	97.17
BG-9	0.57 ab	2.17 b	19.32 f	10.14 cd	20.60 c	5.03	2.15 ab	83.83 cde	100.60
BG-10	0.47 ef	1.58 f	21.82 e	10.32 bcd	16.67 ef	5.20	1.76 a-d	91.05 b-e	98.25
BG-11	0.57 ab	2.17 b	35.62 b	11.56 a	24.95 a	4.86	2.10 a-c	83.67 cde	97.70
BG-12	0.55 abc	1.94 cd	34.09 c	9.73 d	26.04 a	5.26	1.67 b-d	91.45 b-e	99.12
BG-13	0.54 bcd	2.05 bc	37.99 a	9.89 cd	21.23 c	4.75	1.98 a-d	78.70 e	100.10
BG-14	0.42 f	1.29 g	10.15 l	9.41 d	10.45 i	5.53	1.58 d	126.70 a	99.50
BG-15	0.51 cde	2.13 b	30.85d	10.59a-d	25.14 a	4.56	2.03 a-d	82.90 de	102.60

Data followed by the same letter within a column do not differ significantly (P≤0.05) by DMRT

(126.70 mg 100g^{-1}) followed by BG-8 (106.70 mg 100g^{-1}). The β-carotene content of the landraces ranged from 95.50 to 106.50 µg 100g^{-1}. The highest β- carotene was found in BG-6 and it was the lowest in BG-1. The higher fruit protein content 2.24 mg 100g^{-1} was recorded in BG-5, while it was minimum (1.58 mg 100g^{-1}) in BG-14.

DISCUSSION

The small fruited bitter gourd is an unprivileged and under estimated vegetables in Indian subcontinent although having high medicinal virtues (Peter and Abraham, 2007; Bates *et al.*, 1995). At present, numerous landraces are being cultivated in the country but their morpho-physiological studies related to yield potential have not been explored comprehensively. A synchrony of staminate and pistillate flower is the major limitation of greater yield of this vegetable. The results indicated a tendency of early initiation of staminate flowers than pistillate one. Staminate flowers appeared in 7th node and continued acropetally whereas pistillate flowers initiated at 11th node and continued onwards. This is a general phenomenon of the flower initiation in cucurbits where inflorescence is solitary and racemose type (Ram *et al.*, 2002b). The appearance of pistillate flowers in the basal node leads to the production of greater number of fruits. The induction of flowers in different landraces varied due to inherent characters of the landraces. Mohanty and Mishra (1999) reported 4.6 to 8.8 nodes for first staminate bearing and 15.5 to 27.0 nodes for first pistillate flower bearing pattern in pumpkin landraces, and the significant differences were found in nodes for first staminate and pistillate flower in same plant. There was a tendency of being lower staminate to pistillate ratio in small size fruit behavior landraces compared to oblong fruit size landraces. Rajput *et al.* (1996) and Rasul *et al.* (2004) found a wide range of variations among the landraces in respect of flowering habit.

It is revealed that yield was mainly contributed by number of pistillate flowers, average fruit weight and number of fruit per plant. This yield attributes are influenced by morpho-physiological characters like vine length, primary branches, leaf area and chlorophyll content (Mia *at al.*, 2012; Mia and Shamsuddin, 2011; Ram *et al.*, 2002a). Significant variations in morpho-physiological attributes were observed among the landraces which might be due to genetic makeup and the finding was supported by Islam *et al.* (2009) who found that morphological characters were influenced by genotype-environment interaction and environmental linear effects. The fruit weight had maximum direct bearing on yield, and the greater fruit yield might be due to cumulative effect of higher number of branches per vine, individual fruit weight and higher number of fruit plant^{-1}. There was a general tendency of giving lower yield in the small size fruit inducing landraces. On the other hand, larger oblong fruit bearing landraces produced greater fruit yield. Therefore, vine length, primary branches, leaf area, fruit length and number of fruit per vine contributed directly to yield. Bhave *et al.* (2003) also reported that vine length, number of branches vine^{-1}, fruit length, average fruit weight and seed number fruit^{-1} had the highest positive direct effects on fruit yield. The frequency of pistillate flowers was also induced by endogenous hormone synthesis which contributed yield potential that was supported by Saimbhi *et al.* (2006) and Behera *et al.* (2009). But present results indicated that increased number of pistillate flowers are not always enhanced the fruit yield which might be decreased the fruit size. Our results showed fruit size is the direct indicator of yield increment. More the number of fruits per vine, smaller will be the fruit size. Therefore, major emphasis should be given on selection of landraces having more number of fruits plant^{-1}, average fruit weight, fruit length and fruit diameter which would lead to the development of high yielding cultivars of bitter gourd.

Significant (P≤ 0.05) differences in rind thickness and weight were found among the landraces, and the highest rind thickness was recorded in landrace BG-5 and it was least in BG-14 landrace. The rind thickness is proportional to the size of fruit especially the length of fruit. It is interesting that larger rind thickness was found in oblong fruit bearing landraces compared to small and round type landraces. The higher flesh thickness also associated with fruit length and size to accommodate the fruit biomass (Dey *et al.*, 2006). Reduction of seed content is the desirable approach for improvement of bitter gourd however, seedless bitter gourd loose the original taste and medicinal value of the vegetable. Generally, the small size fruits contained less number of seeds. Considerable variation was observed in respect to different nutritional aspect in different bitter gourd landraces. Ascorbic acid and total soluble solid (TSS) contents of fruits were the highest in BG-14 followed by BG-5 and BG-8. The highest TSS was found in BG-14 and it was the lowest in BG -15. The variation in the chemical composition in these cultivars suggests that there is scope for *M. charantia* breeding for high yield and nutritive value (Paul and Raychaudhuri, 2010).

***Conclusions*:** The results indicated that days to initiation of staminate and pistillate flowers varied from 39.4 to 51.17, and both staminate and pistillate flowers were first induced in genotype BG-11. The lowest ratio of staminate to pistillate flower was obtained in genotype BG-3. Staminate flowers initiated on the basal node namely 7th and continued acropetally whereas pistillate flowers initiated from 11th node and continued onward. Small and round fruit bearing genotypes produced greater number of pistillate flowers. On the other hand, all genotypes produced the greater number of staminate flowers than pistillate flowers. Lesser number of fruit induced genotypes produced the larger individual fruit weight. The results also found variations in fruit quality attributes namely total soluble solid, ascorbic acid, β-carotene and protein content which created great potentiality for developing high yielding and quality bitter gourd through breeding.

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