RESEARCH ARTICLE

DISTRIBUTION OF SEX PHENOLOGICAL CHARACTERS AMONG BITTER GOURD (*MOMORDICA CHARANTIA* L.) GENOTYPES AND ITS CORRELATION WITH YIELD POTENTIAL

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Abstract: Bitter gourd (*Momordica charantia* L.) is one of the most popular vegetables in India. The natural flowering behavior of bitter gourd to produce a greater number of pistillate flowers than staminate flowers is the major limitation for the yield improvement. Fifty-three genotypes of bitter gourd were evaluated for the sex phenology, yield and yield contributing characters. The wild genotype AC-16/25 can be marked as an early variety based on sex phenology. The number of pistillate flowers and number of fruits per plant was found to be the highest in JJNS-15/65. Even though, a greater number of pistillate flowers and fruits per plant were produced by the wild genotypes, the fruit yield per plant was found to be the highest in cultivated *charantia* types. A significant positive correlation was observed between yield per plant and other yield contributing characters *viz.,* fruit weight, fruit length, fruit width and flesh thickness.

Keywords: Bitter gourd, Correlation, Pistillate, Sex phenology

INTRODUCTION

Bitter gourd (*Momordica charantia* L.), a member of Cucurbitaceae family, is an important commercial vegetable crop grown in India, Sri Lanka, Philippines, Thailand, Malaysia, China, Japan, Australia, tropical Africa, South America and the Caribbean. *M. charantia* was believed to be of Asian origin till a recent study using mitochondria and plastid DNA based markers revealed that this species is most likely of African origin (Schaefer and Renner, 2010). Based on Rheede's description of the taxa in his *Hortus Malabaricus* (Rheede, 1688), bitter gourd was originally described by Linnaeus (1753) from Peninsular India. It is now found naturalized in all tropical and subtropical regions.

India is endowed with great diversity in this crop. Both the botanical varieties of *M. charantia viz.,* var. *muricata* for the wild material and var. *charantia* for the domesticated one (Chakravarty, 1990) are preferred by consumers. The north Indians prefer long, or medium long spindle shaped glossy green fruits whereas south Indians require long but white fruits. The eastern parts of the country prefer small and dark green fruits (var. *muricata*) (Dey *et al.,* 2010). Even though, wild bitter gourd has close resemblance to cultivated varieties, they can be easily identified by the smaller size of fruits and seeds (Bharathi and John, 2013). This difference makes it an under-utilized vegetable apart from its high medicinal virtues when compared to c*harantia* types (Peter and Abraham, 2007; Bates *et al.,* 1995).

Naturally, this monoecious plant induces more staminate flowers than pistillate flowers, with a mean male to female ratio of 25:1 (Palada and Chang, 2003). This is a common problem in bitter gourd cultivation, since this flowering behavior results in lower fruit set and yield. In order to have higher yield, the staminate and pistillate flower ratio need to be synchronized (Ram *et al.,* 2000). The flowering behavior of bitter gourd varies with cultivar, climatic conditions and cultural practices (Deshpande *et al.,* 1979; Rajput *et al.,* 1996).So, the germplasm lines having higher sex ratio and pistillate flowers than the cultivated varieties have an important role in breeding programmes for developing high yielding crop varieties (Dey *et al.,* 2007).

In this background, the study was taken up to evaluate the distribution of characters representing sex phenology among 53 genotypes of bitter gourd and correlate it with the yield and yield attributing characters.

MATERIALS AND METHODS

Fifty genotypes of bitter gourd belonging to *Momordica charantia* var. *muricata* and three check varieties *viz.,* Preethi, Priyanka and Pusa Purvi were used for the present investigation. Preethi and Priyanka are the two most popular varieties of bitter gourd, belonging to *M. charantia* var. *charantia,* released by Kerala Agricultural University (KAU) whereas, Pusa Purvi is the first small fruited bitter gourd variety developed by Indian Agricultural Research Institute (IARI), New Delhi. It is the only variety of *muricata* type released from India. The details of experimental materials are presented in Table 1.

Among the 50 bitter gourd genotypes, 24 were collected from the Regional Station of NBPGR at Thrissur and 26 from the farmer's fields and wild habitats across Kerala, Karnataka and Tamil Nadu.

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All the 50 *M. charantia*var. *muricata* types were raised in augmented block design along with three check varieties *viz.*, Preethi, Priyanka and PusaPurvi. There were 10 blocks and each block had 5 accessions of wild bitter gourd genotypes and three check varieties. The collected accessions were planted in the pits of size 60 x 60 x 30 cm. The spacing between the pits and row was 3 × 3 m. five plants were maintained per accession. All the recommended agronomic practices were followed as per the package of practices of Kerala Agricultural University (KAU, 2011) for raising a good and healthy crop. The plants were supported by installing pandals with bamboo and nets.

Twelve quantitative characters representing the sex phenology of bitter gourd accessions were observed. Node number at which first pistillate flower appeared was recorded at first appearance of female flower. Days to first pistillate flower was noted from each accession as number of days from sowing date to the date when first female flower open and when at least 50 per cent of the plants of each accession showed first female flower, it is recorded as days to 50 per cent flowering. Total number of pistillate flowers produced by each accession was also noted.

Number of days from date of sowing to the date of first marketable fruit harvest was counted as days to first fruit harvest. Number of fruits of each accession was counted after every harvest and total number of fruits per plant was recorded. The weight of an average of 10 random fruits from each accession at marketable stage was recorded as fruit weight and cumulative yield of all pickings in each accession as yield of fruits per plant. The length, width, flesh thickness and cavity size of fruits were recorded as an average of 10 random fruits at marketable stage.

RESULTS AND DISCUSSION

The variability in flowering phenology is represented in Fig. 1. The characters like node number for first female flowering, days to first female flowering, days to 50 per cent flowering and days to first fruit harvest decides the sex tendency and earliness of a variety. Rajput *et al.* (1996) and Rasul *et al.* (2004) found a wide range of variation among the genotypes of bitter gourd in respect of flowering habits.

The lowest node number for first female flowering was observed in the accession, AC-16/16 (13.51), which is on par with AC-16/25 (14.94). Islam *et al.* (2009) also observed the appearance of female flowers of bitter gourd genotypes at 13 to 21 nodes. In this study, the flowers initiated at lowest nodes in wild genotypes when compared to *charantia*types. This difference in flower initiation reflects the genetic characters of the genotypes. The lower the node number, the higher the female tendency and earlier the variety (Shiefriss and Galun, 1956).Mohanty and Mishra (1999) reported 15.5 to 27.0 nodes for first pistillate flower bearing in pumpkin landraces.

The minimum number of days required for the opening of first pistillate flower was found in AC-16/25 and the maximumin the cultivated variety, Priyanka. Minimum days for 50 per cent pistillate flowering were taken by AC-16/25 and IC 582439 (49.33 and 49.74 respectively) and the check variety, Priyanka took 73.56 days. The days to first fruit harvest was least in the accession AC-16/25 (57 days). This may be because of the earlier initiation of first pistillate flower in this accession (40 days). The first fruit harvest was delayed up to 80.53 days in Priyanka.

The distribution of days to first pistillate flower opening, 50 per cent flowering and first fruit harvest followed similar pattern among 53 genotypes of bitter gourd. From Fig. 1, a close relationship can be found between these three sex determining characters. In all the genotypes which have taken minimum days for first female flower opening, days to 50 per cent flowering and first fruit harvest were the earliest. Considering these characters, AC-16/25 can be marked as an early variety with lowest node number for first female flowering (14.94), minimum days to first pistillate flower appearance (40), minimum days to 50 per cent flowering (49.33) and minimum days to first fruit harvest (57).

The distribution of number of pistillate flowers and number of fruits per plant among the bitter gourd genotypes are depicted as Fig. 2. The number of pistillate flowers per plant was highly influenced by different genotypes. The highest number of pistillate flowers was produced by JJNS-16/65 (179.71) while, the lowest number was found in Priyanka (17.78). The number of flowers per plant was more in small fruit bearing *muricata* genotypes than in cultivated varieties like Preethi and Priyanka (Fig. 2). The flower initiation at lower nodes in wild genotypes might have played a significant role in producing a greater number of flowers. The frequency of pistillate flowers, which contributes to higher yield, was induced by endogenous hormone synthesis (Saimbhi and Takur (2006), Behera *et al.* (2009)).

The highest number of fruits per plant was recorded in the same accession with highest number of pistillate flowers *i.e..,* JJNS-15/65. A positive linear relationship was found between the number of pistillate flowers and fruits per plant (Fig. 2). As the number of female flowers increased, the number of fruits produced also increased. Both these yield contributing characters were found to be the highest in the accession JJNS-15/65 (179.71 numbers of pistillate flowers and 168.39 numbers of fruits per plant). Majority of the wild genotypes of bitter gourd produced a greater number of pistillate flowers and fruits than the cultivated c*harantia* varieties (Fig. 2). It might be due to the presence of larger number of primary and secondary branches in these wild genotypes (Islam *et al.*, 2014).

Variability in yield and yield contributing characters are illustrated in Fig. 3 and 4. Variability in fruit length, width, flesh thickness and cavity size are given in Fig. 3. Length and width of fruit was the lowest in the accession AC-16/15 (2.13 cm and 1.05 cm) and the highest in Priyanka (16.32 cm and 4.21 cm). The highest flesh thickness was recorded in the variety Priyanka (1.42 cm) and it was low (0.15 cm) in the accessions JJNS-15/39, AC-16/8, AC-16/21 and IC 541231. Cavity size varied from 0.88 cm to 3.12 cm with maximum value in Priyanka and minimum in AC-16/15 (Fig. 3). The highest flesh thickness was also associated with fruit length and fruit size to accommodate the fruit biomass (Dey *et al.*, 2006). The parameters of fruit like length, width, flesh thickness and cavity size were the highest in cultivated varieties of var. *charantia* (fig. 3). As per the description of *muricata* types, all the collected wild genotypes showed lower fruit size. This may be the reason for the low acceptability of this high medicinal valued vegetable among the farmers.

Variability in individual fruit weight and yield among accessions of bitter gourd is depicted in Fig.4. The average weight of individual fruit also varied significantly among accessions due to genotypic variation and ranged from 3.53 g (IC 582403) to 420.61 g where Priyanka produced the heaviest fruit (Fig. 4). Among the wild genotypes, IC 467681 showed highest individual fruit weight of 50.15 g with a fruit yield of 969.44 g. It was observed that with the increase in fruit length and width, the fruit weight was also increased.

The highest fruit yield was recorded in the cultivated variety of bitter gourd, Preethi, which was significantly higher from all other genotypes (Fig. 4). The fruit yield was the lowest in the wild accession, IC 467673 (124.05 g).Even though the wild genotype, JJNS-15/65 produced highest number of pistillate flowers and fruits, it did not produce higher yield (900.38 g). The results demonstrated that the average fruit weight directly contributed to fruit yield than number of pistillate flowers and fruits per plant. Fruit yield is the direct contribution of individual fruit weight and number of branches per plant (Islam *et al.*, 2014).

Even though, a greater number of fruits were produced by the *muricata* accessions, other yield contributing characters like fruit weight, length, breadth, flesh thickness and cavity size were found to be higher in the commercial *charantia* varieties. The highest fruit length, width, flesh thickness and cavity size were observed for IC 467681 among the wild types, but the fruit yield was only 969.44 g per plant with 19.33 fruits per plant. The fruit yield per plant was the highest in Preethi (8568.61) followed by Priyanka (6023.14) and AC-16/1 (1493.88).

For all these sex phenological characters, Pusa Purvi, the cultivated variety of *muricata* type, showed similarity with that of other wild genotypes.

From this study it is revealed that yield was mainly contributed by fruit weight, fruit length, fruit width, flesh thickness and cavity size. The characters like number of pistillate flowers and number of fruits per plant also contributed towards the yield but, the role played by these characters is very low when compared to other fruit characters. These yield attributes are influenced by morpho-physiological characters like vine length, primary branches, leaf area and chlorophyll content (Mia *et al*., 2012; Mia and Shamsuddin, 2011; Ram e*t al*., 2002). Present study also showed that the fruit size is the direct indicator of yield increment. Therefore, major emphasis should be given on selection of genotypes having a greater number of fruits per plant, high average fruit weight, fruit length and fruit diameter which would lead to the development of high yielding cultivars of bitter gourd.

Correlation studies

Determination of correlation between yield and yield contributing characters is necessary in any hybridization programme (Khan *et al.*, 2015). Correlation measures the mutual association between two variables, which aids in determining the most effective procedures for selection of superior genotypes. When there is positive association for major yield components, breeding would be very effective. Simple correlation co-efficient was made among eleven important yield components towards yield of bitter gourd accessions. The values of 'r' and the components correlated are presented in Table 2.

Correlation co-efficient revealed that days to first female flower and first fruit harvest showed positive and highly significant correlation with fruit yield/plant (0.559; 0.494), fruit weight (0.571; 0.494), fruit length (0.362; 0.313) and flesh thickness (0.374; 0.314). This indicates that the days to first fruit harvest, yield per plant, fruit weight, and length and flesh thickness will be increased with the increase of days to first female flowering. Node order for first female flowering showed positive correlation with fruit weight only. Number of nodes to first female flowering is a fair measure of both sex tendency and maturity. Lower the node number, the higher will be the female tendency and earlier will be the variety (Shiefriss and Galun 1956). Shawaf and Baker (1981) found high genotypic and phenotypic correlations between nodal position of first pistillate flower and yield.

Number of pistillate flowers had a significant positive correlation with number of fruits per plant and significant negative correlation with individual fruit weight, fruit length, fruit width and flesh thickness. As the number of pistillate flowers increases number of fruits per plant increases. The increase in fruit number will decrease the fruit size.

With the respect to fruit characters, fruit length (0.708), fruit width, (0.552), individual fruit weight (0.966), flesh thickness (0.781) and cavity size (0.437) had high degree of significant positive

association with yield per plant. This indicates that these traits could contribute for higher yields. But number of fruits per plant showed a non-significant relationship with total yield per plant and a positive correlation with number of female flowers. These findings disagree with the findings of Ananthan and Pappiah (1997), Li *et al.* (1997), Khan *et al.* (2015) and stated that days to first female flowering and days to first picking was negatively correlated with yield per plant, fruit length, fruit diameter and individual fruit weight. They also found a positive correlation between number of fruits per plant and yield. This contradiction may be because of the difference in the bitter gourd genotypes under study.

Table 1. The bitter gourd genotypes used for the study

Sl. No.	Accessions	State/ district	Source of collection
Accessions of *M. charantia*var. *muricata*			
1	JJNS-15/12	Madhya Pradesh	NBPGR
2	JJNS-15/39		
3	JJNS-15/43		
4	JJNS-15/62		
5	JJNS-15/65		
6	IC 213312	Kerala	
7	IC 467681		
8	W 84	Andaman & Nicobar	
9	IC 541231	Tamil Nadu	
10	IC 541235		
11	IC 541248		
12	IC 467673	Kerala	
13	IC 467645		
14	IC 541377	Andaman & Nicobar	
15	IC 582403		
16	IC 582439	Rajasthan	
17	IC 582471		
18	IC 598168	Mizoram	
19	IC 598170		
20	IC 598171		
21	IC 598172		
22	W 154		
23	W 172	Punjab	
24	W 173		
25	AC-16/1	Vellanikkara	Thrissur, Kerala
26	AC-16/2		
27	AC-16/3	Mannuthy	
28	AC-16/4	Kuthiranmala	Palakkad, Kerala
29	AC-16/5		
30	AC-16/6		
31	AC-16/7	Bathery	Wayanad, Kerala
32	AC-16/8		
33	AC-16/9	Thodupuzha	Idukki, Kerala
34	AC-16/10	Alacode	
35	AC-16/11	Karuvanchal	Kannur, Kerala
36	AC-16/12	Chemperi	
37	AC-16/13	Mundakkayam	Kottayam, Kerala
38	AC-16/14	Erumeli	
39	AC-16/15	Kanchiyar	Idukki, Kerala
40	AC-16/16	Kattapana	
41	AC-16/17	Thrichinapally	Tamil Nadu
42	AC-16/18		
43	AC-16/19		
44	AC-16/20	Salem	
45	AC-16/21	Pazhani	
46	AC-16/22		
47	AC-16/23	Indira Nagar	Bangalore, Karnataka
48	AC-16/24		
49	AC-16/25		
50	AC-16/26		

Check varieties			
51	Preethi	COH, Vellanikkara	KAU
52	Priyanka	RARS, Ambalavayal	
53	PusaPurvi	IARI, New Delhi	IARI

Table 2. Correlation coefficients for selected quantitative characters of bitter gourd genotypes

Characters	Days to first female flower opening	Node order for first female flower	No. of Female flowers	Days to first fruit harvest	No. of fruits/plant	Yield/ plant	Fruit weight	Fruit length	Fruit width	Flesh thickness
Node order for first female flower	0.038									
No. of female flowers	-0.041	-0.224								
Days to first fruit harvest	0.992**	0.003	-0.002							
No. of fruits/plant	-0.062	-0.216	0.989**	-0.026						
Yield/ plant	0.559**	0.253	-0.192	0.495**	-0.158					
Fruit weight	0.571**	0.277*	-0.320*	0.495**	-0.286*	0.966**				
Fruit length	0.362**	0.150	-0.410**	0.313*	-0.405**	0.708**	0.734**			
Fruit width	0.184	0.165	-0.298*	0.128	-0.277*	0.552**	0.554**	0.757**		
Flesh thickness	0.374**	0.249	-0.397**	0.314*	-0.364**	0.726**	0.781**	0.776**	0.693**	
Cavity size	0.125	0.078	-0.183	0.105	-0.163	0.437**	0.422**	0.665**	0.928**	0.504**

**Significant @ 1% P, * Significant @ 5%.

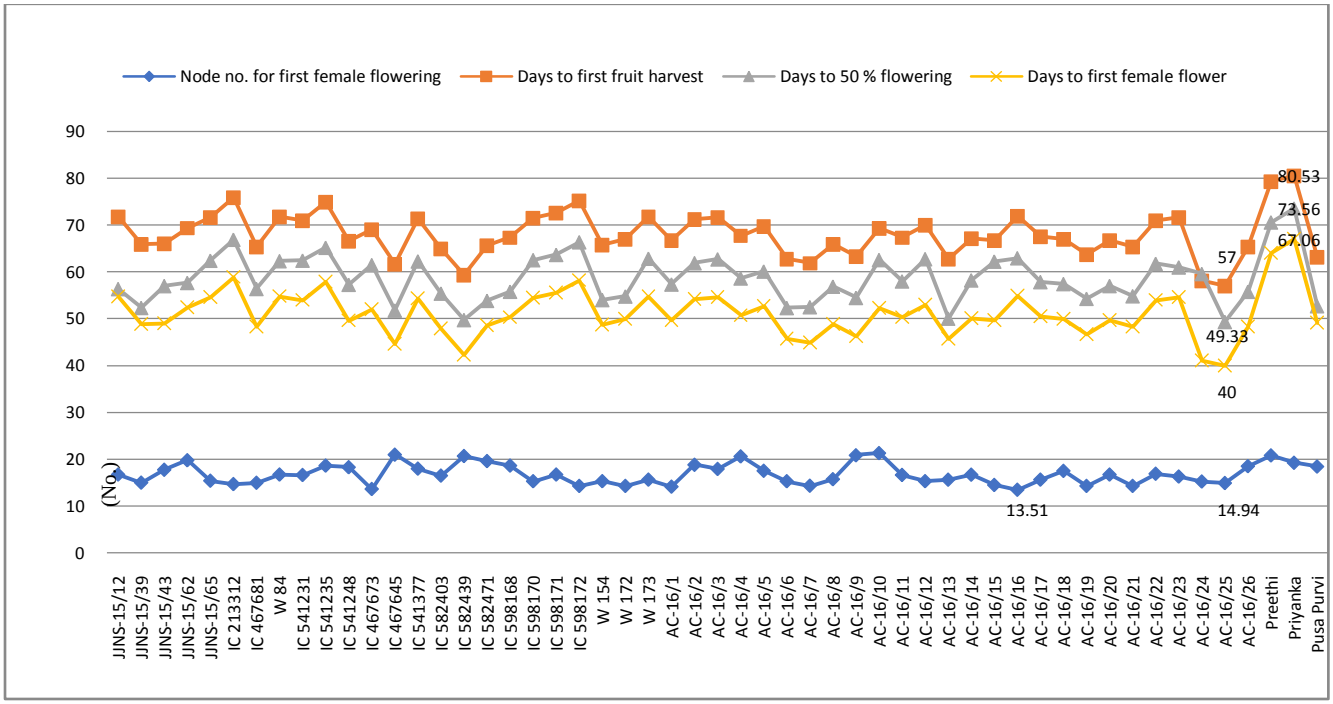

Fig. 1. Variability in flowering phenology of bitter gourd genotypes

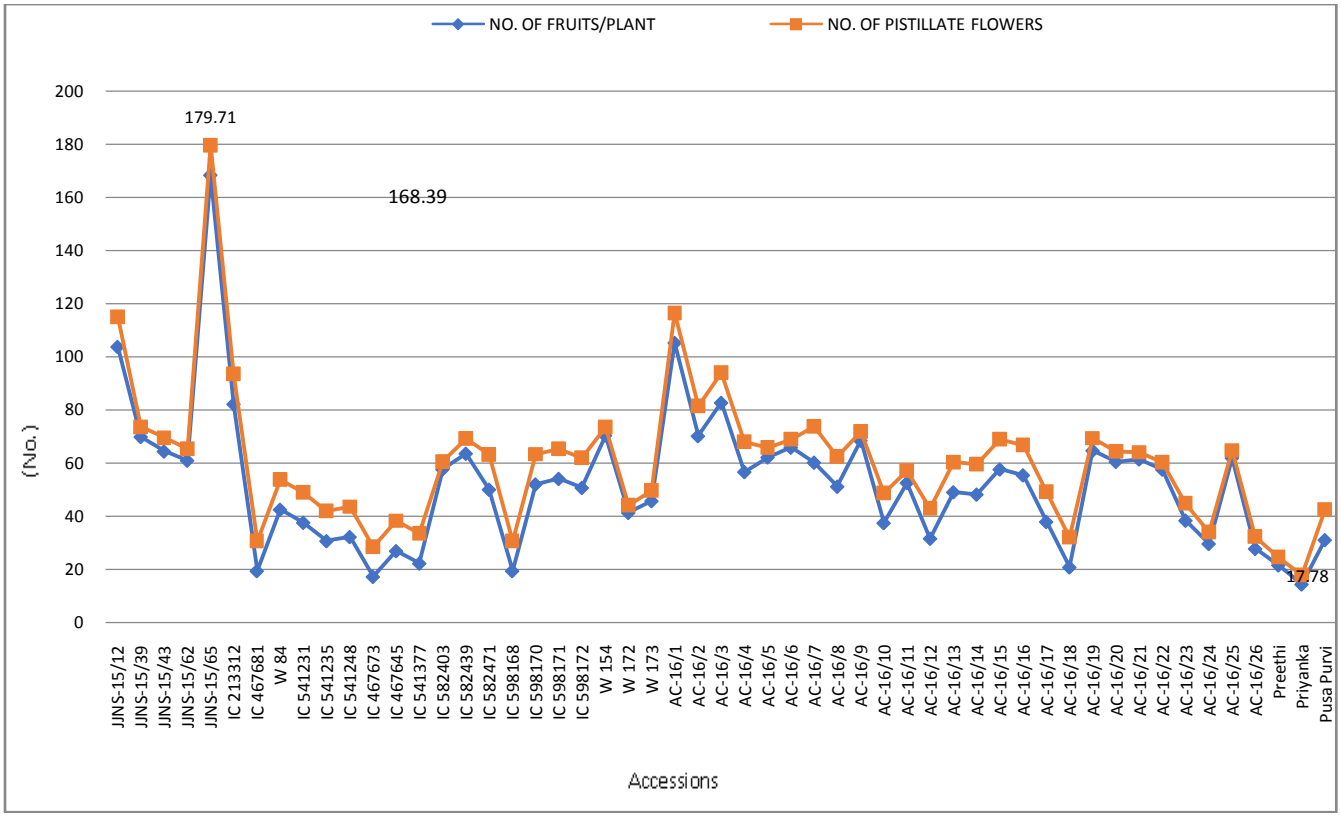

Fig. 2. Variability in number of pistillate flowers and number of fruits per plant of bitter gourd genotypes

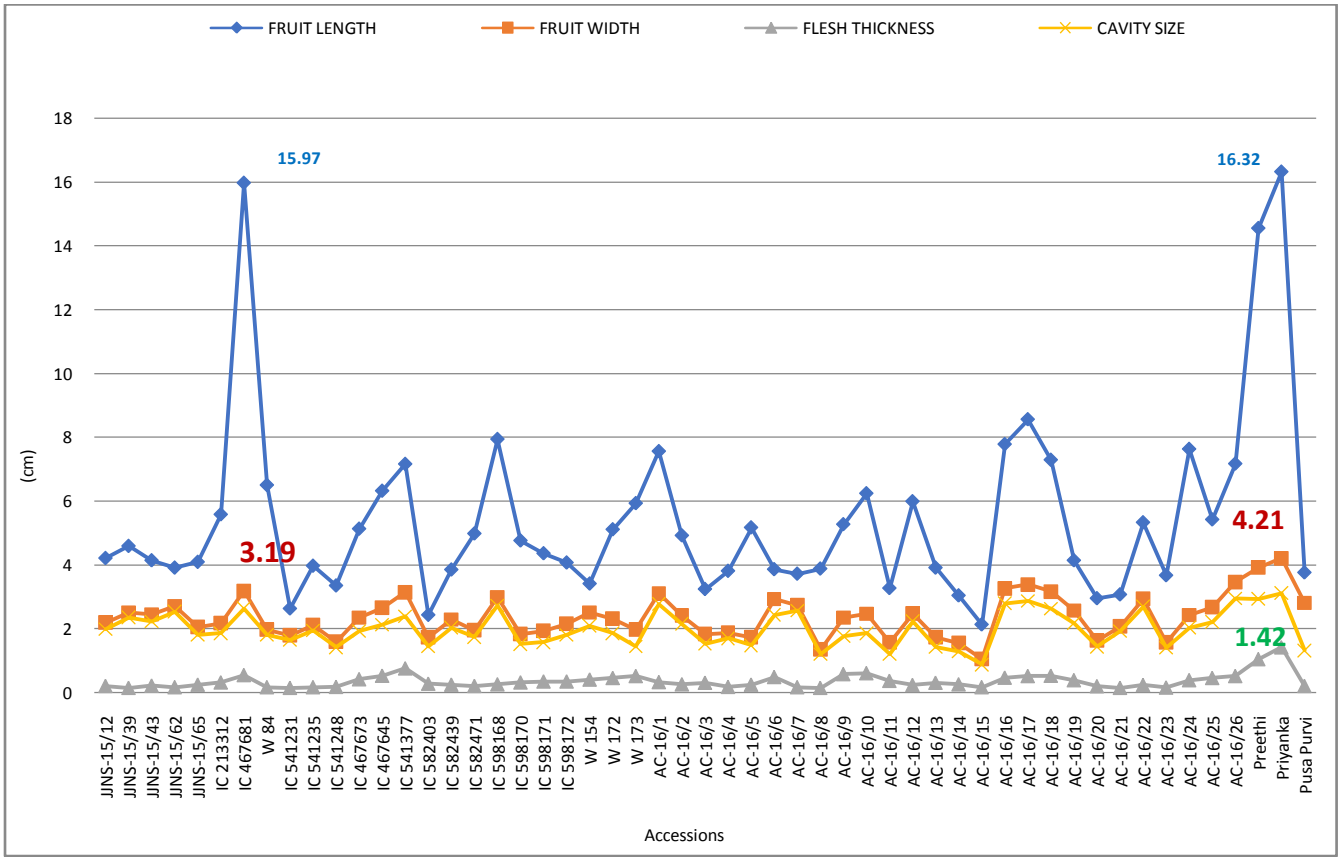

Fig. 3. Variability in quantitative characters of fruits of bitter gourd genotypes

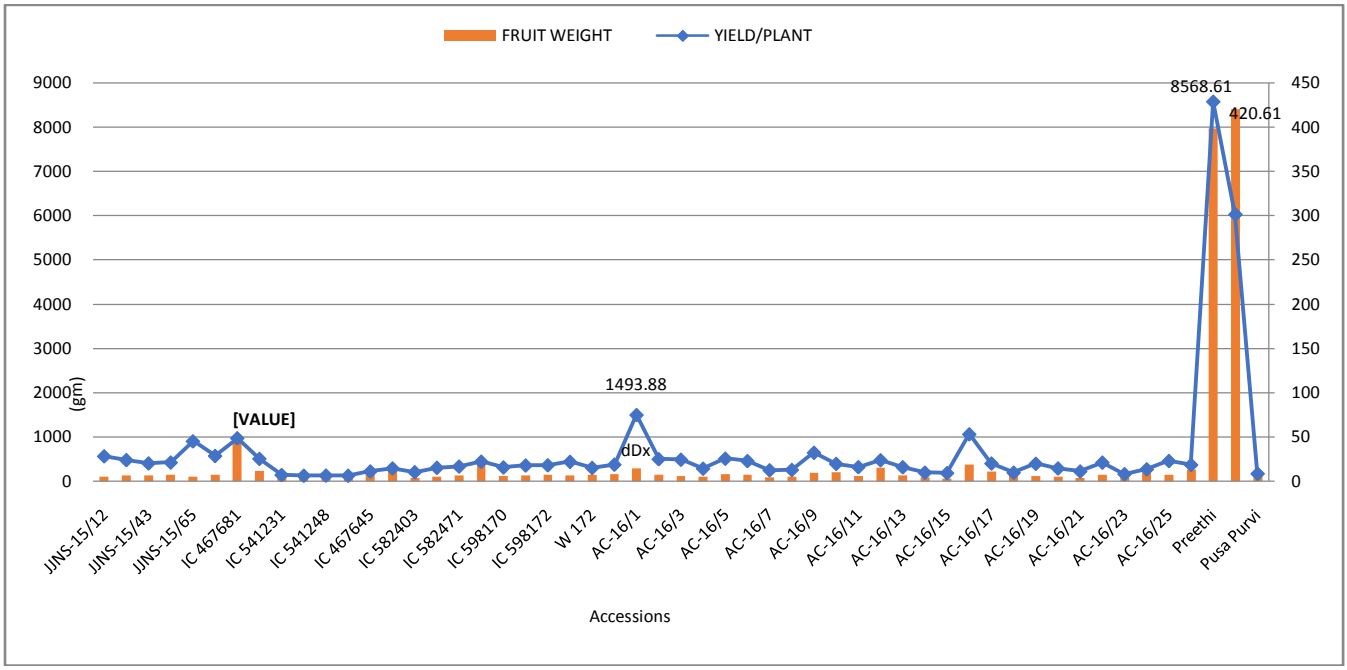

Fig. 4. Variability in yield per plant and individual fruit weight of bitter gourd genotypes

CONCLUSION

Small fruit bearing wild genotypes of bitter gourd produced greater number of pistillate flowers than cultivated varieties. Lesser number of fruit induced genotypes produced the larger individual fruit weight. The results also found great potentiality of wild genotypes for developing high yielding bitter gourd through breeding.

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