

RESEARCH ARTICLE

Characterization of Gola *Ber* Genotypes under Arid Conditions of Western Rajasthan for Qualitative and Quantitative Characters

DK Sarolia*, Kamlesh Kumar, Lokesh Kumar, D Singh and MK Choudhary

Abstract

About 350 genotypes of *ber* are being maintained at the National Active Germplasm Site (NAGs) of ICAR-CIAH, Bikaner, Rajasthan. These *ber* accessions were characterized for two consecutive years to assess variability among the accessions for qualitative and quantitative characters. In *ber*, ambiguity exists in local nomenclature as a result of different names in different localities for the same cultivar and the same name for different cultivars. For instance, Gola collected from different locations (CAZRI, HAU, IARI, MPKV, Bahadurgarh, Jodhpur) with another name (Delhi Gola, Gola Gurgaon, Kakrola Gola, and Popular Gola) may be the same name for different genotypes, i.e., Sasni Gola entirely different than original Gola. In this context, sixteen different Gola genotypes were collected earlier from different locations and characterized to assess similarity or dissimilarity among the genotypes on morphometrically and fruit quality traits basis. These 16 *ber* genotypes showed a range of variability with respect to plant growth, yield attributes and fruit quality parameters. The canopy volumes ranged from 12.21 to 19.84 m³, leaf size (length 7.2–11.5 cm and width 4.5–6.7 cm), and fruit yield 50.4 to 75.2 kg/plant. Further, fruit quality in terms of fruit weight, TSS, TSS acidity, total sugars and ascorbic acid content ranged from 18.5 to 28.8 g, 25.2 to 30.6° Brix, 60.71 to 89.53, 13.23 to 16.40% and 76.8 to 82.2 mg/100 g of edible pulp, respectively. Among sixteen genotypes, three have been found superior and showed marked variability with respect to fruit shape, size and color etc. viz., Gola CIAH (Diggi No.1) genotype recorded with the biggest fruit size, round fruit shape and golden yellowish color followed by Gola CIAH (N-1) and Gola Gurgaon (S3-5). Quality-wise, genotypes Gola CAZRI (S1-1) and Gola MPKV (S6-13) were found to be better than rest of the genotypes. Moreover, these genotypes were marked for further exploitation as commercial multiplication.

Keywords: Gola *ber* genotypes, Growth and Quality traits.

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Received: 07/01/2022 **Revised:** 02/04/2024

Accepted: 30/05/2024

How to cite this article: Sarolia DK, K Kumar, L Kumar, D Singh and MK Choudhary (2024) Characterization of Gola *Ber* Genotypes under Arid Conditions of Western Rajasthan for Qualitative and Quantitative Characters. *Indian J. Plant Genet. Resour.* 37(2): 310-315.
DOI: 10.61949/0976-1926.2024.v37i02.14

Introduction

Ber (*Ziziphus mauritiana* Lamk.) belongs to the family Rhamnaceae and is said to be an indigenous fruit crop. According to De Condolle (1886), the center of origin of *ber* is Central Asia, where it is found under varying climatic conditions. It is grown in India traditionally from ancient times, where it has been in use for almost 4000 years (Mittre, 1961). It is one of the most suitable fruit trees for arid and semi-arid regions. It is also known as Chinese date, Chinese fig or poor man's fruit. It is distributed worldwide, including the Indian sub-continent, Southeast Asia, Australia, China, Africa, the Mediterranean region and the American center but its cultivation is confined over drier parts of the globe and commercial cultivation occurs in India. It is an example of an extremely drought-hardy species and is a dominant component of the natural vegetation of the Indo-Pak deserts. Both leaves and fruits of *ber* are very important from a nutritional point of view for being richer in mineral contents (Ivanova, 1982), vitamin C (Wang *et al.*, 1992) and other important nutritional contents. In both China and India, *Ziziphus* varieties have a long tradition of selection and cultivation, which

resulted in better-known and more widely released varieties than in other regions (Cherry, 1985). The important Indian states for jujube cultivation are Punjab (Sangrur, Bathinda, Ferozpur, Ludhiana, Patiala, and Mukatsar), Haryana (Hisar, Rohtak, Jind, Panipat, Mahendergarh and Gurgaon), Uttar Pradesh (Varanasi, Aligarh, Ayodhya and Agra), Rajasthan (Bharatpur, Jaipur and Jodhpur), Gujarat (Banaskantha, Sabarmati, Bhavnagar, Surendranagar, Patna, Ahmedabad, Bharuch, Vadodara, Sabarkantha and Mehsana), Tamil Nadu (Tirunelveli, Ramanathapuram, Dharmapuri and Salem), Karnataka (Bijapur, Bellary, Gulbarga, Belgaum, Raichur and Bidar), West Bengal (Murshidabad, Malda, Bankura and Birbhum), etc (Fig. 1). Presently, in India area under *ber* cultivation is around 54,000 ha with a production of 596,000 MT annually (Sawant *et al.*, 2023). More than 300 varieties of *ber* are available in the various parts of the country due to the suitability of the edapho-climatic conditions that prevailed in the region, but only a few are commercially important. They are Gola, Seb, Mundia; suitable for extremely dry areas, whereas Banarasi Kadaka, Umran and Meharun are suited for comparatively humid regions (Chadha, 2019). Various scientists have reported genetic and morphological variation among *ber* cultivars due to one or other reasons.

In northern India, Gola is the earliest to ripen, the ruling variety and covers about 60% area of *ber* cultivation (Anonymous, 2018). Gola has spreading tree habit, leaf cordate, broad (L/W: 1.1); apex obtuse; old leaves curved towards the ventral surface; broad-based. The petiole is light green in color on both surfaces, having an average length of 1.2 cm. Flowering starts late in August, with a peak in early September and ends late in September. Fruit set starts early in September with a peak late in September and ends early in October. Fruits mature earlier (January 7-25) than other commercial varieties. Fruit round; style end flat; stem end round; skin bright yellow, smooth and glossy; the cavity in pericarp at stem end; pulp white, soft; size 3.8 x 3.5 cm; pulp/stone ratio 14.3; average weight 21.4 g; TSS 21°Brix. Chovatia *et al.* (1992) have reported 160 mg/100 g vitamin C content in fruit pulp of this variety.

At farmer's fields a lot of complaints arise in the Gola genotype regarding poor flowering, pollination, fertilization, fruit set and fruit shape, size, yield, etc. The possible solution might be related to genuine of planting material, edapho-climatic factors and, crop bounded agro techniques, etc. Present climatic variables influencing a lot to the genotypic performance which needs reassessments in such conditions. In the case of *ber*, considerable confusion has arisen as a result of different names in different localities for the same cultivar and the same name for different cultivars. For instance, Gola collected from different locations (CAZRI, HAU, IARI, MPKV, Bhadurgarh, Jodhpur) with another name (Delhi Gola, Gola Gurgaon, Kakrola Gola, and Popular Gola) may be the same name for different genotypes, i.e., Sasni

Gola entirely different than original Gola. Therefore, the present study was conducted at ICAR- Central Institute for Arid Horticulture, Bikaner on existing Gola genotypes which were earlier collected from different localities such as CAZRI, HAU, IARI, MPKV, Bhadurgarh, Jodhpur with the nomenclature as Delhi Gola, Gola Gurgaon, Kakrola Gola, Laddu Gola, Popular Gola etc. with prefix or suffixed as Gola to know the similarity or dissimilarity morphometrically and fruit quality wise. The evaluation and improvement of *ber* for Rajasthan need to be intensified with genuine saplings of superior fruit quality. Keeping in view the above facts present study was conducted to evaluate and utilize the existing variability of the *ber* for crop improvement.

Materials and Methods

A field observation trial was conducted on *ber* cv. Gola genotypes were collected from different sources and planted at varied locations at ICAR - Central Institute for Arid Horticulture, Bikaner, situated in the middle of Thar desert at N 28.12°N latitude, 73.34° E longitude and at an altitude of 234.84 m above sea level. This is a national active germplasm site and maintains the largest field repository of *ber* crop in the country. In the present experiment, full-grown trees were selected having almost uniform age groups (15 years); three trees of each genotype planted at a spacing of 6 x 6 m that were collected earlier from different locations and being maintained in a field gene bank. A selective sampling method was adopted for the selection of genotypes of Gola *ber* and tagged with recording geographical position with the help of hand-held GPS device (Garmin Ltd.) and numbered as 1. Gola CAZRI (S1-1), 2. Gola, Jodhpur (S1-21), 3. Gola, Gudgaon, (S3-5), 4. Gola Kakrola (S4-6), 5. Gola CIAH (N-1) in nursery, 6. Gola by cuttings (N -2) in nursery, 7. Gola CIAH (N-3) in nursery, 8. Gola CIAH (Diggi No.1), 9. Gola HAU (S1-25), 10. Gola Laddu (S2-28), 11. Gola CIAH (R-1), 12. Gola Kakrola (Rahuri S4-7), 13. Gola Popular-Hisar (S6-9), 14. Gola MPKV (S6-13), 15. Gola Kakrola (Bhadurgarh S8-17) and 16. Gola IARI (S9-17). The study in each genotype was conducted during two consecutive years *i.e.*, 2018-19 and 2019-20. Observations with respect to plant growth (plant type, lead size, canopy volume, fruit load, shape) and fruit quality (fruit weight, fruit size, stone weight, pulp weight, pulp: stone, shape index, TSS, acidity, sugars, ascorbic acid) attributes were recorded at right stage and following standard methodology mentioned in descriptor of *ber* crop (Anonymous, 2017), especially canopy volume (m³) calculated by formula = $r^3 \times (2/3 X + X^3/3)$ whereas r = canopy radius and x = canopy height (Reddy *et al.*, 2008). Further, the fruit sample comprising 15 mature fruits of each accession was used for the physicochemical analysis. Fruit weight, stone and pulp weight were determined on electronic balance and fruit diameter was measured by use of Vernier caliper and shape index by dividing equatorial to polar diameter. Total

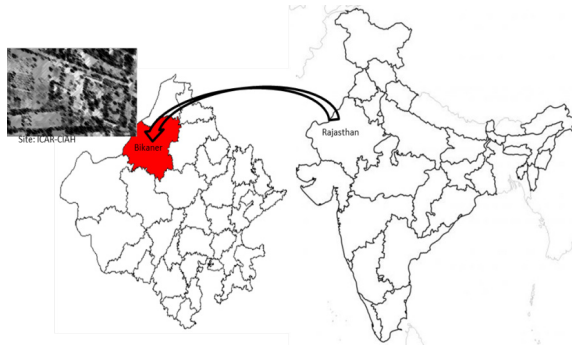


Fig. 1: National active germplasm site (NAGs) of Indian jujube

soluble sugars (TSS) content was recorded with the help of a hand refractometer and readings were corrected at 20°C with the help of a temperature correction chart. However, titratable acidity, total sugar, reducing sugars and ascorbic acid contents were determined as per standard methods described by AOAC (1990). All data were statistically analyzed by one way of analysis of variance using statistical online OPSTAT software developed by Sheoran *et al.* (1998).

Results and Discussion

Plant Growth and Yield

It is evident from the data presented in Tables 1, 2 and 3 that variability exists with respect to plant growth characteristics, fruit yield and quality attributes in the analyzed genotypes of Gola *ber*. From the observations, it was noticed that all genotypes have plant type tall or bushy, spreading type canopy with medium to dense foliage density. The canopy volume of Gola genotypes varied from 12.21 to 19.84 m³, leaf length 7.5 to 11.5 cm and width 4.5 to 6.7 cm. Variation in fruit yield was also noticed and fruit yield ranged from 50.4 to 75.2 kg plant per plant. Gola CIAH (N-3) genotype recorded maximum canopy volume (19.84 m³) followed by (19.02 m³) Gola HAU (S1-25) and minimum in Gola IARI (12.21 m³). Likewise, the highest yield (75.10 kg/plant) also noted in genotype Gola CIAH (N-3) and the lowest (50.40 kg/plant) in Gola IARI. This wide difference in canopy and yield among Gola genotypes probably might be due to differences in the genetic makeup of the each genotype (Table 1), which need to be study for clear conformity as also supported by Abdel-Sattar *et al.* (2021) who observed similar disparities in growth and yield attributes among eleven Indian *ber* cultivars. They suggested that variations among genotypes may arise from genotype-specific traits and their edapho-climatic suitability in a specific region, a notion previously supported by Mahajan and Dhillon (2000) and Kumar *et al.* (2014).

Physical Fruit Quality Parameters

Fruiting load from all genotypes was observed as medium to heavy. Fruits of all 16 Gola genotypes were round in shape (shape index value 0.95–1.02) and yellowish in color

at maturity with average fruit weight, pulp weight and pulp: stone varied from 18.5 to 28.8 g, 17.29 to 26.90 g and 13.04 to 14.50, respectively. Maximum fruit weight (28.80 g) and diameter (3.68 cm polar and 3.50 cm equatorial) was registered in Gola CIAH (D-1) followed by Gola CIAH (N-1), i.e., 22.80 g and minimum in Gola Kakrola (18.50 g). Similarly, pulp weight was also noted as a maximum (26.90 g) in Gola CIAH (D-1) and a minimum (17.29 g) in Gola Kakrola. Further, the highest (1.90 g) stone weight was recorded in Gola CIAH (D-1) and the lowest (1.20 g) in Gola Popular genotype, which was at par with Gola Kakrola (S4-7). Whereas pulp:stone ratio was found to be a maximum (14.50) in Gola Popular and a minimum (13.04) in Gola CIAH(N-2) (Table 2). The fruit weight, pulp weight, and pulp: stone ratio displayed variability among the Gola *ber* genotypes examined. Various researchers have documented similar observations in their studies on *ber* varieties, including investigations by Razi *et al.* (2013), Islam *et al.* (2015) and Abdel-Sattar *et al.* (2021).

Biochemical Quality Attributes of Gola Genotypes

As far as biochemical fruit quality traits are concerned, the TSS content among 16 Gola genotypes ranged from 25.2 to 30.6 °B. The highest TSS content (30.6°B) was noticed in the Gola CAZRI genotype planted at N28°6'3 E 73°20'4 site, followed by Gola MPKV (30.1°B) and minimum in Gola Laddu (25.2°B). The TSS: acidity ratio and ascorbic acid content in these genotypes also varied from 60.71 to 89.53 and 76.8 to 82.2 mg/100 g pulp, respectively. Further, total sugar, reducing sugars and non-reducing sugars ranged from 13.23 to 16.40%, 6.02 to 7.55% and 7.74 to 9.71%, respectively. Maximum sugars (16.40%) were found in the Gola CAZRI genotype, closely followed by (16.14%) Gola MPKV (N28°6'4 E 73°20'5) and Gola Kakrola (15.47%), Rahuri (N28°6'4 E 73°20'5). The minimum respective fruit quality traits *viz.*, TSS (25.2°Brix), total sugar (13.23%), and reducing sugars (6.02%) were registered in Gola Laddu (N28°6'4 E 73°20'4). All these Gola genotypes did not register any significant difference with respect to acidity and ascorbic acid content.

The fruit quality attributes, such as total soluble solids (TSS) and the TSS: acidity ratio, exhibited noticeable variation among the examined *ber* genotypes. However, no significant differences were observed among these Gola genotypes in terms of acidity and ascorbic acid content. These findings closely align with those reported by Chen *et al.* (2019). Variations in TSS values may be attributed to climatic differences in the region and the genetic makeup of the cultivar, as noted by Shukla *et al.* (2007). The accumulation of ascorbic acid in fruits is primarily influenced by genotype, cultivation conditions and management practices (Chen *et al.*, 2019). The findings of the present study regarding titratable acidity and ascorbic acid are negatively correlated with the results of Abdel-Sattar *et al.* (2021). They found varied titratable acidity (0.38–1.27%) and ascorbic acid contents (55.27–164.47 mg/100 g) in eleven studied Indian

Table 1: Characterization of *Ber* cv. Gola accessions for growth and yield attributes

S. No	Genotype Gola and site of plantation	GPS position of plant	Plant type and foliage density	Canopy volume (m ³)	Fruit shape and color	Leaf length and width (cm)	Fruiting load	Yield (kg/plant)
1	Gola CAZRI (S1-1)	N28° 6' 3" E 73° 20' 4" Elevation 194.8 m	Bushy spreading plant with heavy foliage density	13.01	Big round and yellow color	11.4 x 6.6	Heavy	74.2
2	Gola Jodhpur (S1-21)	N28° 6' 4" E 73° 20' 4" Elevation 211.7m	Bushy spreading plant with medium foliage density	17.05	Big round and yellow color	7.2 x 4.5	Medium	68.4
3	Gola Gudgaon, (S3-5)	N28° 6' 4" E 73° 20' 5" Elevation 201.9m	Bushy compact plant with heavy foliage density	18.79	Big round and yellow color	8.8 x 5.1	Medium	70.6
4	Gola Kakrola (S4-6)	N28° 6' 4" E 73° 20' 5" Elevation 206.1m	Tall spreading plant with medium foliage density	12.91	Medium round and yellow color	10.2x5.1	Medium	60.7
5	Gola CIAH(N-1)	N28° 7' 2" E 73° 21' Elevation 197.3 m	Tall spreading plant with heavy foliage density	18.76	Medium round and yellow color	9.6 x 5.8	Heavy	75.1
6	Gola by cuttings CIAH(N-2)	N28° 6' 4" E 73° 21' Elevation 203.6 m	Bushy spreading plant with dense foliage density	18.87	Medium round and yellow color	11.5 x 6.2	Medium to heavy	70.4
7	Gola CIAH (N-3)	N28° 6' 1" E 73° 20' Elevation 196.3 m	Bushy spreading plant with dense foliage density	19.84	Medium round and yellow color	9.0 x 5.1	Medium to heavy	75.5
8	Gola CIAH (Digg No.1)	N28° 6' 9" E 73° 21' Elevation 217.3 m	Tall spreading with medium foliage density	17.96	Big round and yellowish	10.4 x 5.6	Medium	70.3
9	Gola HAU (S1-25)	N28° 6' 1" E 73° 20' 3" Elevation 198.6 m	Tall spreading plant with medium foliage density	19.02	Medium round and yellow	9.4 x 5.5	Medium	71.4
10	Gola Laddu (S2-28)	N28° 6' 4" E 73° 20' 4" Elevation 190.5m	Bushy spreading compact plant with medium foliage density	15.78	Big large, round and yellowish	10.6 x 6.7	Heavy	72.1
11	Gola CIAH(R-1)	N28° 6' 1" E 73° 20' 3" Elevation 199.6 m	Bushy spreading and medium foliage density	17.54	Medium round and yellow	9.7 x 5.5	Heavy	72.1
12	Gola Kakrola (Rahuri S4-7)	N28° 6' 4" E 73° 20' 5" Elevation 204.7 m	Bushy spreading and medium foliage density	13.96	Medium round and yellowish	9.6 x 5.3	Medium	64.2
13	Gola popular-Hisar (S6-9)	N28° 6' 4" E 73° 20' 5" Elevation 206 m	Bushy spreading and medium foliage density	12.50	Medium round and yellowish dull appearance	9.1 x 5.0	Medium	62.3
14	GolaMPKV (S6-13)	N28° 6' 4" E 73° 20' 5" Elevation 197.7m	Tall spreading medium foliage density	17.66	Medium round and yellowish	8.4 x 4.5	Medium	67.4
15	Gola Kakrola (Bhadurgarh S8-17)	N28° 6' 4" E 73° 20' 5" Elevation 204.4m	Bushy compact medium foliage density	14.00	Medium round and yellowish	8.7 x 5.1	Medium	64.3
16	Gola IARI (S9-17)	N28° 6' 4" E 73° 20' 5" Elevation 203.4m	Tall spreading medium foliage density	12.21	Medium round and yellowish	9.7 x 5.5	Low to medium	50.4
	SEm±	-	-	1.60	-	0.27x 0.14	-	1.92
	CD (p=0.05)	-	-	4.80	-	0.80x0.41	-	5.78

ber cultivars and reported that these differences are due to the unique genetic makeup of each cultivar.

Thus, *ber* genotype 'Gola CIAH (D-1)' was recorded big size (28.80 g) round fruit and golden yellowish color followed

by (22.80 g) Gola CIAH (N-1), which was at par (22.70 g) with Gola Gudgaon (S3-5). However, yield potential was found to be maximum (75.50 kg/plant) in genotype Gola CIAH(N-3), closely followed by (75.10 kg/plant) Gola CIAH (N-1) and Gola

Table 2: Evaluation of *Ber* cv. Gola for physical fruit quality traits

S. No	Genotype Gola and site of plantation	Fruit weight (g)	Stone weight (g)	Pulp weight (g)	Pulp/Stone	Fruit diameter (cm)		Shape index (E/P)
						Polar	Equatorial	
1	Gola CAZRI (S1-1)	22.02	1.50	20.52	13.68	3.50	3.42	0.98
2	Gola Jodhpur (S1-21)	21.05	1.40	19.65	14.04	3.62	3.50	0.97
3	Gola Gudgaon, (S3-5)	22.70	1.50	21.20	14.13	3.37	3.30	0.98
4	Gola Kakrola (S4-6)	19.28	1.33	17.95	13.50	3.13	3.20	1.02
5	Gola CIAH(N-1)	22.80	1.60	21.20	13.25	3.44	3.39	0.98
6	Gola by cuttings CIAH(N-2)	19.66	1.40	18.26	13.04	3.18	3.09	0.97
7	Gola CIAH (N-3)	22.61	1.60	21.01	13.13	3.40	3.35	0.98
8	Gola CIAH (Diggi No.1)	28.80	1.90	26.90	14.16	3.68	3.50	0.95
9	Gola HAU (S1-25)	21.50	1.50	20.00	13.33	3.38	3.33	0.98
10	Gola Laddu (S2-28)	22.08	1.50	20.58	13.72	3.34	3.40	1.02
11	Gola CIAH(R-1)	21.20	1.45	19.75	13.62	3.22	3.24	1.01
12	Gola Kakrola, (Rahuri S4-7)	18.50	1.21	17.29	14.29	2.96	2.99	1.01
13	Gola popular-Hisar (S6-9)	18.60	1.20	17.40	14.50	2.79	2.76	0.98
14	Gola MPKV (S6-13)	19.20	1.30	17.90	13.77	2.71	2.62	0.97
15	Gola Kakrola (Bhadurgarh S8-17)	20.40	1.40	19.00	13.57	2.99	2.95	0.99
16	Gola IARI (S9-17)	20.40	1.40	19.00	13.57	3.00	2.96	0.99
SEm±		2.23	0.35	1.88	1.79	0.39	0.35	0.27
CD (p=0.05)		6.69	1.05	5.64	5.37	NS	1.05	NS

Table 3: Evaluation of *Ber* cv. Gola for biochemical quality traits

S. No	Genotype Gola and Site of plantation	TSS (°B)	Acidity (%)	TSS/Acidity ratio	Total sugar (%)	Reducing sugars (%)	Non reducing sugars (%)	Ascorbic acid (mg/100g)
1	Gola CAZRI (S1-1)	30.60	0.38	80.53	16.40	7.55	9.71	78.80
2	Gola Jodhpur (S1-21)	25.50	0.42	60.71	13.23	6.09	7.84	82.20
3	Gola Gudgaon (S3-5)	27.10	0.41	66.10	14.06	6.48	8.33	80.60
4	Gola Kakrola (S4-6)	28.80	0.40	72.00	14.95	6.88	8.85	79.00
5	Gola CIAH(N-1)	27.40	0.41	66.83	14.22	6.55	8.42	80.60
6	Gola by cuttings CIAH(N-2)	29.10	0.40	72.75	15.10	6.95	8.94	80.00
7	Gola CIAH (N-3)	26.30	0.40	65.75	13.65	6.29	8.08	79.00
8	Gola CIAH (Diggi No.1)	28.10	0.40	70.25	14.58	6.72	8.64	78.70
9	Gola HAU (S1-25)	28.70	0.40	71.75	14.90	6.86	8.82	78.60
10	Gola Laddu (S2-28)	25.20	0.41	61.46	13.08	6.02	7.74	80.60
11	Gola CIAH(R-1)	27.20	0.41	66.34	14.12	6.50	8.36	80.60
12	Gola Kakrola (Rahuri S4-7)	29.80	0.39	76.41	15.47	7.12	9.16	77.40
13	Gola Popular-Hisar (S6-9)	28.00	0.40	70.00	14.53	6.69	8.60	79.00
14	Gola MPKV (S6-13)	30.10	0.38	79.21	16.14	7.43	9.56	76.80
15	Gola Kakrola (Badurgarh S8-17)	28.50	0.40	71.25	14.79	6.81	8.76	79.00
16	Gola IARI (S9-17)	26.00	0.41	63.41	13.49	6.21	7.99	80.60
SEm±		2.07	0.02	3.78	1.07	0.49	0.61	2.09
CD (p=0.05)		6.21	NS	11.34	3.22	1.48	1.83	NS

CAZRI (S1) (74.20 kg/plant). Additionally, fruit quality-wise, *ber* genotypes Gola CAZRI (S1-1) and Gola MPKV (S6-13) were found to be better than the rest of the genotypes. Moreover,

these tagged genotypes (Gola CAZRI, Gola CIAH (N-1 & 3) and Gola CIAH (D-1) can be used for further propagation due to better yield and quality of *ber* fruits.

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