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GENETIC DIVERSITY IN *BER* (*ZIZIPHUS MAURITIANA* LAM.) VARIETIES FOR LAC PRODUCTION

J. GHOSH*, V. D. LOHOT, V. SINGHAL, S. GHOSAL AND K. K. SHARMA
Lac Production Division, ICAR-Indian Institute of Natural Resins and Gums, Ranchi - 834 010, INDIA
e-mail: jghoshranchi@gmail.com

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***Corresponding author**

ABSTRACT
Farmers grow lac on land races of ber, often whose fruits are of no desirable taste. Fruit varieties of *ber* have potential to yield good lac and in case of failure of lac crop they will produce marketable fruit. Genetic diversity serves as a way to adopt fruit varieties of *ber* to changing environments for lac production. It will improve livelihood security of tribal farmers in lac growing area. Present experiment was carried out on fruit varieties of *ber* in experimental plot of Institute Research Farm of IINRG, Ranchi during 2011-12 and 2012-13. Fruit *ber* varieties had adequate genetic variation, high heritability (72.5-84.6%) coupled with high genetic advance as percent of mean (92.5-221%) for chlorophyll content index, reducing sugar, soluble protein and scrapedlac yield. Therefore, phenotypic selection for genetic improvement of these traits will be effective as these traits are under the control of additive gene action. *Ber* varieties were grouped in three distinct clusters on the basis of morphological, biochemical and physiological markers. Cluster I had 9 varieties, cluster II with 10 varieties (with five varieties of cluster I) and cluster III with 9 varieties (with six common varieties of Cluster II). Most of the high scrapedlac yielding varieties (*Seb X Gola* F_1, *Jogia, Kaithali, Banarasi Karka*) lie in cluster III. Rest of the four varieties including CAZRI *Gola* was not able to form any cluster in this analysis. Genetic manipulation in *ber* varieties can be done by making divergent crosses to develop potential varieties of *ber* for lac production.

INTRODUCTION

The genus *Ziziphus* contains about 86 species (Evreinoff, 1964; Johnston, 1972) but Bhansali, 1975 and Liu and Cheng, 1995 have suggested that there could be up to 135 species. Genetic diversity of *Ziziphus* spp. in India is high and about 20 species are found between 8.5-32.5ºN and 69-84ºE. Jujube or Indian plum or *ber* (*Ziziphus mauritiana* Lam) is an economically important tropical fruit tree which is grown all over the drier parts of the Indian subcontinent for its fresh fruits (Awasthi and More, 2009). *Ber* is a fast-growing and hardy tree that copes with extreme environment including drought and saline water (Chrovatia *et al*., 1993, Mizrahi and Nerd 1996, Clifford *et al.,* 1998) and thrives under rather dry conditions (Pareek, 2001). It plays an important role in supporting livelihood income, employment, folk medicine, timber and livestock fodder (Azam *et al.,* 2005). Being cross pollinated crop, large variability in the seedling population has taken places which allow making a rich gene pool. Segmental allopolyploidy in *Ziziphus* plays an important role in creating variability (Khoshoo and Singh, 1969). The ability of *Ziziphus* species and different varieties/types within *mauritiana* to cross freely has allowed the buildup of rich gene pool which is heterozygous in terms of adaptability to soil and climate; morphological, physiological and phenological traits and tolerance/ resistance to biotic and abiotic stresses**.**

Lac cultivation is a profitable option of agriculture for farmers of Jharkhand, Chhattisgarh, Odissa, Madhya Pradesh, West Bengal *etc,*. (Ghosal, 2013). Although *ber* tree is well known for its fruit value but has special importance as a host tree for lac insect culture (lac cultivation) on its shoots. *Ber* tree is commercially exploited for lac cultivation in India extensively along with other host trees *palas* (*Butea monosperma*) and *kusum* (*Schleichera oleosa*). It is a very good host for both *rangeeni* and *kusmi* biotypes of bivoltine, *Kerria lacca*, (Kerr). Lac is the scarlet resinous secretion of scale insect; the most common, *Kerria lacca* which yields three useful materials resin, dye and wax. Thousands of these tiny insects colonize the suitable branches of host trees and secrete the resin as a protective covering. Most of the lac growers utilize *Z. mauritiana* for summer season *rangeeni* (*baisakhi*) lac cultivation where *ari* lac (immature) is harvested due to high summer temperature. The *ari* lac is meant for resin value and by the time it is harvested, sufficient amount of resin is already secreted by the insect. For rainy season (*katki)* crop, partial harvesting is carried out leaving some insects to self colonize on the trees in the month of July and finally harvesting in the month of October. As far as *kusmi* crop is concerned, winter crop (*aghani*) is preferred due to absence of leaves in the summer season (Jaiswal and Singh, 2010).Only wild varieties of *ber* have been exploited for commercial lac cultivation in India till date. The vast germplasm with distinctive traits has not been utilized for lac cultivation so far. Therefore, the present study was carried out to know genetic diversity among 23 varieties of *ber* to explore the scope of lac production on fruit varieties.

MATERIALS AND METHODS

The experiment was conducted at Institute Research Farm (IRF) of ICAR-IINRG, Ranchi (Jharkhand) during 2011-12 and 2012-13. The IRF is located at 23.35ºN latitude and 85.33ºE longitude at an elevation of 2140 feet above mean sea level, in southern part of Chotanagpur plateau. Climate is characterized by hot summer from March to May and well distributed rain fall from June to October due to southwest monsoon. Winter season in the area is marked by dry and cold weather during the month of November to February. Generally, the climate of Ranchi is moderate due to hilly region and dense deciduous forest. The soil is formed from the disintegration of rocks and stones. Soil type is alfisols (red gravelly and sandy soils) and ultisols (red and yellow soils) having light textured, slightly acidic, poor in nitrogen and phosphorus and fairly rich in potash.

Twenty three varieties of *ber* had been procured from Central Arid Zone Research Institute (CAZRI), Jodhpur and planted in July 1996 at IRF, IINRG, Ranchi. Details of twenty three *ber* varieties used in this study are presented in Table 1. All trees were pruned in February 2011 to ensure proper shoot development at inoculation time. Adequate new branches emerged in July. *Kusmi* broodlac was inoculated for the first time on few branches of all the varieties of *ber* to raise *aghani* crop (July 2011-Feb 2012). Broodlac was harvested at maturity in February 2012 coinciding with pruning. These *ber* varieties were again inoculated in July 2012 to raise *aghani* crop (July 2012 - Feb 2013). Data were recorded for lac yield attributing traits, biochemical and physiological traits in leaves in three replications.

Initial settlement density was calculated by counting number of crawlers settled in one square centimeter area at three levels of branches (lower, middle and upper). Mean settlement length was calculated by taking an average of settlement length of crawlers on ten branches per tree. Percent initial insect mortality was taken at 30 days after lac inoculation by counting dead crawlers in settled length of one square centimeter. Female to male sex ratio was counted during sex differentiation stage. Broodlac of *Kusmi* (*aghani*) was ready for harvesting at maturity during January-February. Harvested broodlac was weighed for each *ber* variety. The resinous cover was scraped off from the twigs and weighed as scrapedlac.

Fresh leaf samples were taken at 11 to 12 noon from inoculated trees of each *ber* variety for biochemical analysis. The sugars were determined by Nelson's arsenomolybdate method (Nelson, 1944) using improved copper reagent of Somogyi, 1952. Non-reducing sugar was calculated by subtracting reducing sugar from total sugar. Soluble protein was estimated by Lowrey's method (Lowrey *et al.,* 1952). Chlorophyll content index (CCI) was measured by chlorophyll content meter (CCM 200, Opti-Sciences). Pooled data were analyzed for variability, heritability, genetic advance using SPAR 2.0. Numerous methods are currently available for analysis of genetic diversity (Thamilarasi, 2013). Here, Hierchical cluster analysis was done for scrapedlac from data on morphological, biochemical and physiological traits using Sigma stat 3.5.

RESULTS AND DISCUSSION

Genetic variability

The genetic parameters of morphological- biochemical-physiological traits in *ber* varieties were studied which help in estimation of genetic variability in a population and suggest

Table 1: List of *ber* varieties with area of cultivation / collection

Sl no	Varieties	Area of cultivation/ collection	Sl no	Varieties	Area of cultivation/ collection
1	Dandan	Punjab, Haryana	13	Seb x Tikadi BC_1	CAZRI, Jodhpur, Rajasthan
2	Aliganj	Uttar Pradesh	14	Chhuara	Punjab, Haryana, Rajasthan, Maharastra, Andhra Pradesh, Tamil Nadu
3	Seb x Katha F_1	CAZRI, Jodhpur, Rajasthan	15	Umran	Maharastra, Punjab, Haryana, Uttar Pradesh, Tamil Nadu, Andhra pradesh
4	Bagwadi	Rajasthan			
5	Illaichi	Uttar Pradesh	16	Jogia	Uttar Pradesh, Rajasthan
6	Thornless	Punjab	17	Banarsi Karaka	Uttar Pradesh, Haryana
7	Maharwali	Rajasthan	18	ZG-3	Punjab, Haryana
8	Kali	Rajasthan	19	Seb	Punjab, Haryana, Rajasthan,
9	CAZRI Gola	CAZRI, Jodhpur, Rajasthan	20	Sanaur 5	Punjab, Haryana
10	Reshmi	Punjab	21	Kaithali	Punjab, Haryana, Maharastra, Gujarat, Tamil Nadu
11	Katha	Punjab, Rajasthan	22	Banarsi Pebandi	Uttar Pradesh
12	Seb x Gola F_1	CAZRI, Jodhpur, Rajasthan	23	Mundia	Uttar Pradesh, Haryana, Rajasthan

Table 2: Genetic parameters of morphological, biochemical and physiological traits in *ber* varieties

Genetic parameter	ISD	MSL	SR	IM%	RS	NRS	TS	SP	CCI	LY	SY
Heritability (Percent)	81.83	68.12	60.71	58.23	84.59	65.28	89.94	83.73	88.77	33.67	72.54
Genotypic coefficient of variations	46.18	31.58	27.77	44.95	70.38	23.47	46.97	65.89	113.84	28.07	52.70
Phenotypic coefficient of variations	51.05	38.27	35.64	58.91	76.52	29.04	49.53	72.01	120.85	48.37	61.87
Genetic advance	71.97	19.66	12.17	10.97	35.38	20.00	87.83	75.95	639.29	131.96	157.08
Genetic advance value % means	86.06	53.70	44.57	70.65	133.34	39.05	91.76	124.20	220.95	33.55	92.46

ISD = Initial settlement density, MSL = mean settlement length, SR = female to male sex ratio, IM% = initial mortality percent, RS = reducing sugar, NRD = non-reducing sugar, TS = total sugar, SP = soluble protein, CCI = chlorophyll content index, LY = broodlac yield, SY = scrapedlac yield.

Table 3: Broodlac and scrapedlac yield in *ber* varieties

Varieties	LY /plant	SY/ plant	Varieties	LY /plant	SY/ plant
Reshmi	207	48	Illaichi	488	334
Seb x Katha F_1	266	85	Kali	496	343
Sanaur 5	268	97	Bagwadi	501	209
Seb	281	185	ZG-3	536	298
Maharwali	324	118	Banarsi Pebandi	595	479
Dandan	378	185	Katha	617*	299
Mundia	422	341	Thornless	632*	263
CAZRI Gola	433	270	Banarsi Karaka	648*	438*
Aliganj	440	112	Seb x Gola F_1	670*	327*
Seb x Tikadi BC_1	460	170	Jogia	691*	419*
Umran	473	294	Kaithali	731*	497*
Chhuara	487	318	CD at 5%	176.39	51.45

LY = Broodlac yield, SY = Scraped lac yield, * = significantly higher than check, CAZRI *Gola*

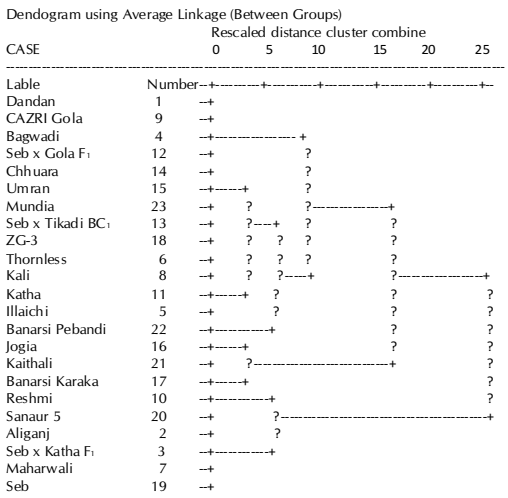
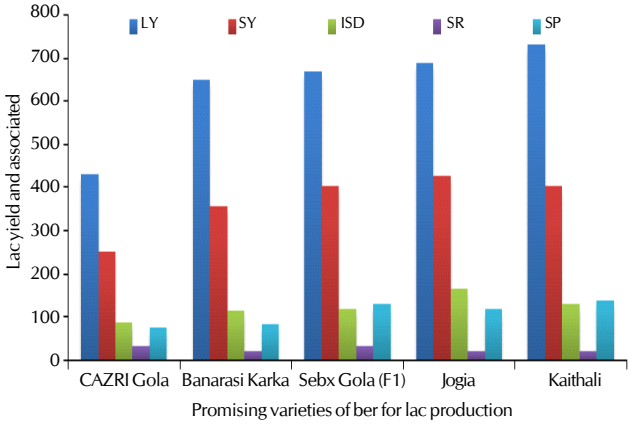


Figure 1: Hierarchial cluster analysis (Dendogram using Ward method) in fruit ber varieties



LY = broodlac yield, SY = scraped lac yield, ISD = initial settlement density, SR = sex ratio, SP = soluble protein

Figure 2: Promising *ber* varieties for lac culture

suitable method for genetic improvement. The parameter like initial settlement density (ISD), reducing sugar (RS), total sugar (TS), soluble protein (SP), chlorophyll content index (CCI) and scrapedlac yield (SY) had moderate to high heritability percent (Table 2). High genotypic and phenotypic coefficient (GCV and PCV) of variation were observed for CCI, RS, SP and SY whereas low values of PCV and GCV were recorded for MSL, LY,SR and non reducing sugar (NRS).Genetic advance (GA) as % means was higher in case of CCI, RS, SP, TS and SY. Mishra *et. al.*, 2000 recorded PCV, GCV, heritability and genetic advance in ber in the range of 18.26-61.31, 18.00-58.92, 0.57-0.99, and 5.65-14.99, respectively.

The estimate of genetic parameters related to morphological-biochemical-physiological traits in *ber* varieties indicates genetic variability in a population and suggests suitable methods for genetic improvement. Presence of adequate genetic variation, high heritability estimates coupled with high genetic advances for RS, TS, SP, CCI and SY indicates that these traits are under the control of additive gene action and phenotypic selection for their improvement may be effective.

Genetic diversity

Hierarchical Cluster Analysis (using Ward Method) was calculated by squared Euclidean distance and used Average Linkage (Between Groups). It grouped 23 *ber* varieties in three distinct clusters (Fig. 1). Groups that merge at high values relative to the merger values of their subgroups are candidates for natural clusters (Tibshirani *et al.*, 2001). Cluster I had 9 varieties (*Bagwadi*, *Seb* x *Gola* F_1, *Chhuhara, Umran, Mundia, Seb x Tikadi* BC_1, *ZG 3, Thornless, Kali*), cluster II with 10 varieties (with last five varieties of cluster I) and cluster III with 9 varieties (with six common varieties of Cluster II). Rest of the four varieties (*Dandan*, CAZRI *Gola*, *Maharwali* and *Seb*) was not able to form any cluster in this analysis. Within these three distinct groups, four clusters were also observed. An increase of 50 to 69 % in broodlac yield (LY) and 17 to 84 % in scrapedlac (SY) were recorded over check (CAZARI *Gola*) in these four *ber* varieties (Table 3).Most of the high scrapedlac yielding varieties (*Seb X Gola* F_1, *Jogia, Kaithali, Banarasi Karka*) lies in cluster III.

Saha *et al.*, 2013 found 11 *ber* cultivars having good potential for fruit harvesting as well as lac production on evaluation of 26 *ber* varieties using molecular markers, random amplified polymorphic DNA (RAPD) and inter simple sequence repeat (ISSR). Singh *et al.*, 2007 investigated genetic diversity in 47 *Ziziphus mauritiana* and one *Z nummularia* using inter simple sequence repeat (ISSR).They suggested that morphologically similar but genotypically distinct genotype could be potential source for genotype identification.

Based on morphological, biochemical and physiological parameters, four *ber* varieties *i.e., Kaithali, Jogia, Seb x Gola* (F_1) *and Banarasi Karka* over check (CAZARI *Gola*) were identified promising for raw lac production.

It can be concluded that wild Indian plum tree is of little economic value to farmers owing to its poor palatability of fruits, although it is available in large number in the forest areas. Most of the lac growers use this tree for commercial lac production giving not much attention to fruit production. The same is the case with *ber* cultivars, where only tree are grown for fruits giving no importance or lack of awareness about lac production. Vast genetic variation is found in *Ziziphus* species which forms the basis for systematic tree improvement programme.

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