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Genetic variability estimates in Indian jujube (*Ziziphus mauritiana*) under semi-arid conditions of Rajasthan

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ABSTRACT

A study was conducted to analyse the genetic variability for different characters using 20 diverse genotypes of Indian jujube or ber (*Ziziphus mauritiana* Lamk.) during 2014-15 and 2015-16 under semi-arid conditions of Rajasthan. The study comprised 14 year old trees of diverse genotypes of ber, viz. Saphar Chandni, Gola, Tikadi, Phalisa Alwari, Thornless, Katha, Katha Bombay, Tabes Taso, Meharun, Dharkhi, Lakhan, Ilaichi, Pathani, Chhuhara, Nazuk, Kheera, ZG-3, Kathaphal, Sukhawani and Ashapuri-2 planted at Asalpur Farm, Department of Horticulture, SKN College of Agriculture, Jobner, Jaipur, Rajasthan in RBD replicated thrice. Analysis of variance revealed that there are highly significant difference among the 20 genotypes tested for all characters studied indicating the presence of variability. The PCV value was relatively greater than GCV for all traits. High GCV along with high heritability and genetic advance as percent of mean was found in fruit weight, volume of fruit, pulp weight, pulp: stone ratio, total acidity, ascorbic acid, TSS: acid ratio and fruit yield/ tree therefore, these characters may be of great importance to a breeder in selecting a desirable genotype.

Key words: Genetic advance, Genetic variability, Heritability, Indian jujube,

Indian jujube or ber (*Ziziphus mauritiana* Lamk.) belongs to family Rhamnaceae, consists of 45 genera and 550 species. It is indigenous to India and one of the most ancient and common fruits in India (Rai and Gupta 1994). Ber is widely distributed in tropical and subtropical regions of the world (Mukhtar *et al*. 2004). It is found wild as well as in cultivated forms throughout the warmer regions up to an altitude of 1500 m amsl. Ber is cultivated in Madhya Pradesh, Bihar, Punjab, Haryana, Gujarat and Rajasthan. Ber is quite popular due to high economic returns, low cost of cultivation, wider adaptability and ability to stand with drought (Chadha and Pareek 1993). It can provide food security, due to sustained production of the fruit, irrespective of drought, as the tree is drought and saline tolerant and can grow on poor degraded land (Pareek 2001). Ber fruits are very nutritious and usually eaten fresh. Fruits are also consumed in dried and preserved form as candy, pickle, juice and ber butter (Maydell 1986).

Arid and semi-arid regions are now facing a grave situation because of ecological deterioration. These areas have been subjected to unprecedented biotic pressure creating variety of scarcity conditions. Inherently, desert environment imposes biophysical constraints for intensive production. Therefore, there is need for greater attention on drought and heat tolerant fruit tree species and ber is the most predominant among them. Out of more than 90 cultivars of ber, only 11 are commonly cultivated in different agro-climatic regions of India (Morton 2005). The choice of a suitable cultivar is of paramount importance for its success. Ber demonstrates a rich genetic diversity mostly resulting from natural cross-pollination and self-incompatibility (Bhargava *et al.* 2005). The breeding strategy for genetic improvement of fruit yield and its components depend upon the genetic diversity for different traits. The assessment of genetic variability parameters is a pre-requisite for making effective selection and improvement in the base population. Thus the present study was conducted to find out the best suited genotype of ber for semi-arid conditions of Rajasthan.

MATERIALS AND METHODS

The present study was conducted during two consecutive years of 2014-15 and 2015-16 to analyze the genetic variability analysis in 20 ber genotypes under semi-arid conditions of Rajasthan. The genotypes consisted of Saphar Chandni, Gola, Tikadi, Phalisa Alwari, Thornless, Katha, Katha Bombay, Tabes Taso, Meharun, Dharkhi, Lakhan, Ilaichi, Pathani, Chhuhara, Nazuk, Kheera, ZG-3, Kathaphal, Sukhawani and Ashapuri-2 of 14 year age planted in Randomized Block Design with three replications at Asalpur Farm, Department of Horticulture, SKN College of Agriculture, Jobner, Jaipur, Rajasthan.

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The soil of experimental site was loamy sand in texture, alkaline with low in available nitrogen and phosphorus and medium in potash. The pH and Ec of water were 8.5 and 5.2 dS/m respectively during 2014-15 and 8.7 and 6.1 dS/m respectively during 2015-16. The mean daily maximum and minimum temperature during the growing season of experimental crop fluctuated between 20.2 to 30.7^{0}C and 3.3 to 13.0^{0}C, respectively during 2014-15. The corresponding values for 2015-16 were between 18.5 to 32.5^{0}C and 2.3 to 14.2^{0}C. Similarly, the mean daily relative humidity fluctuated between 52 to 70% during 2014-15 and 50 to 77% during 2015-16. Rainfall received during the crop period was 21.2 and 19.0 mm during 2014-15 and 2015-16, respectively. The observations were recorded on 29 traits of growth, flowering, fruiting, quality and yield during both the years and pooled analysis was done.

The pooled data were subjected to analysis of variance following standard statistical methods (Panse and Sukhatme 1961 and Singh and Choudhary 1985). The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated as suggested by Burton (1952) and Johanson *et al.* (1955). Heritability in broad sense was calculated by the formula given by Johnson *et al.* (1955) and Hanson *et al.* (1956) and was multiplied by 100 (Lush, 1940) to get it in percentage. The genetic advance for each character was calculated by formula as given by Lush (1940) and Johnson *et al.* (1955).

RESULTS AND DISCUSSION

The mean squares due to genotypes for all characters showed significant difference, indicating the presence of wide range of variability in ber (Table 1). The general mean values, range, variance, coefficient of variation, heritability and genetic advance as percentage of mean of different traits are given in Table 2 and 3 in pooled analysis.

The range in mean values, an indicator of variability revealed wider variation for canopy volume from 57.46 (Sukhawani) to 363.55 m^3 (Chhuhara), stem girth from 28.19 (Sukhawani) to 63.85 cm (Meharun), duration of flowering from 49.83 (Tikadi) to 80.50 days (Sukhawani), duration of fruiting from 40.17 (Sukhawani) to 68.83 days (Gola), fruit weight from 2.58 (Sukhawani) to 16.73 g (Katha), volume of fruit from 2.64 (Sukhawani) to 15.88 cc (Katha), pulp weight from 1.81 (Sukhawani) to 15.58 g (Katha), pulp : stone ratio from 3.02 (Sukhawani) to 16.03 (Thornless), total days taken to first harvesting from 127.33 days (Gola) to 177.83 days (Sukhawani), total days taken to complete harvesting from 184.67 days (Gola) to 237.83 days (Sukhawani), fruit set from 5.44 (Sukhawani) to 20.77% (Gola), fruit drop from 39.58 (Gola) to 83.88% (Sukhawani), fruit retention from 19.94 (Sukhawani) to 55.95% (Gola), TSS from 9.70 (Sukhawani) to 23.14% (Meharun), ascorbic acid content from 50.24 (Sukhawani) to 200.98 mg/100 g pulp (Lakhan), TSS: acid ratio from 18.91 (Kathphal) to 178.22 (Tikadi) and fruit yield/tree from 5.77 (Sukhawani) to 26.43 kg (Gola). The range was found to be quite low for the characters, viz. plant height from 2.79 (Sukhawani) to 4.84 m (Chhuhara), plant spread (E-W) from 3.16 (Sukhawani) to 6.67 m (Saphar Chandni), plant spread (N-S) from 3.06 (Sukhawani) to 6.34 m (Saphar Chandni), fruit length from 1.45 (Sukhawani) to 4.21 cm (Thornless), fruit breadth from 1.52 (Sukhawani) to 2.88 cm (Gola), stone weight from 0.46 (Ilaichi) to 1.45 g (Gola), specific gravity from 0.85 (Sukhawani) to 1.20 (Katha), number of fruit pickings from 5.67 (Sukhawani) to 11.17 (Gola), total acidity from 0.12 (Sukhawani) to 1.06% (Kathaphal), total sugars from 5.53 (Sukhawani) to 9.95% (Meharun), reducing sugar from 2.21 (Sukhawani) to 6.78% (Gola) and non-reducing sugar from 2.39 (Gola) to 4.75% (Ilaichi).

Table 1 Analysis of variance for growth, flowering, fruiting attributes, quality and yield attributes in ber (Pooled data)

Character	Replications df (2)	Genotypes df (19)	Error df (38)
Plant height (m)	0.03	0.88*	0.46
Plant spread E-W (m)	0.26	3.03**	0.54
Plant spread N-S (m)	0.70	2.74**	0.40
Canopy volume (m3)	1611.86	25491.07**	2405.10
Stem girth (cm)	69.20	333.55**	51.60
Duration of flowering (days)	11.59	183.85**	19.07
Duration of fruiting (days)	14.68	171.27**	13.57
Total days taken to first harvesting	3.85	399.34**	5.20
Total days taken to complete harvesting	44.22	502.76**	14.17
Fruit set (%)	0.04	0.60**	0.03
Fruit drop (%)	0.96	94.27**	2.93
Fruit retention (%)	9.41	254.14**	7.70
Number of fruit pickings	0.87	5.23**	1.65
TSS (%)	1.70	27.54**	2.49
Total acidity (%)	0.0001	0.17**	0.001
Ascorbic acid (mg/ 100 g pulp)	32.31	5148.36**	15.57
Total sugars (%)	0.04	5.48**	0.18
Reducing sugar (%)	0.90	3.49*	0.89
Non-reducing sugar (%)	0.05	1.34**	0.11
TSS: acid ratio	51.96	5941.35**	45.38
Fruit weight (g)	1.05	55.18**	1.46
Volume of fruit (cc)	4.96	49.78**	1.59
Fruit length (cm)	0.03	1.72**	0.06
Fruit breadth (cm)	0.03	1.72**	0.06
Stone weight (g)	0.02	0.18**	0.01
Pulp weight (g)	0.29	51.50**	1.30
Pulp : stone ratio	0.21	48.81**	2.78
Specific gravity	0.006	0.02**	0.03
Fruit yield/tree (kg)	5.82	102.38**	2.15

*Significant at 5% level of significance, **Significant at 1% level of significance.

Comparison of coefficient of variation indicated that the phenotypic coefficient of variation was higher than the

Table 2 Estimates of genetic variability for growth, flowering and fruiting attributes in ber (Pooled data)

Characters	Mean	Range	Genotypic variance	Phenotypic variance	Genotypic coefficient of variation (%)	Phenotypic coefficient of variation (%)	Heritability in broad sense (%)	Genetic advance	Genetic advance as percentage of mean
Plant height (m)	3.68	2.79-4.84	0.17	0.54	11.22	19.92	31.73	0.48	13.02
Plant spread E-W (m)	4.78	3.16-6.67	0.83	1.37	19.08	24.46	60.82	1.47	30.65
Plant spread N-S (m)	4.85	3.06-6.34	0.78	1.18	18.21	22.44	65.89	1.48	30.46
Canopy volume (m^3)	195.34	57.46-363.55	7700.46	10055.76	44.92	51.34	76.58	158.19	80.98
Stem girth (cm)	42.24	28.19-63.85	93.98	145.58	22.95	28.56	64.65	16.05	37.99
Duration of flowering (Days)	68.15	49.83-80.50	57.94	67.96	11.17	12.09	85.26	14.48	21.25
Duration of fruiting (Days)	51.81	40.17-68.83	52.57	66.13	13.99	15.70	79.48	13.32	25.70
Total days taken to first harvesting	158.49	127.33-177.83	131.38	136.58	7.23	7.37	96.19	23.16	14.61
Total days taken to complete harvesting	212.27	184.67-237.83	162.86	177.03	6.01	6.27	92.00	25.22	11.88
Fruit set (%)	11.55	5.54-20.77	0.19	0.22	12.74	13.57	88.19	0.84	24.65
Fruit drop (%)	66.26	39.58-83.88	30.37	33.27	10.08	10.55	91.31	10.85	19.84
Fruit retention (%)	34.52	19.94-55.95	30.61	33.46	15.66	16.37	91.49	10.90	30.86
Number of fruit picking	8.59	5.67-11.17	1.20	2.84	12.72	19.62	42.04	1.46	16.99

genotypic coefficient of variation for all the characters which indicated effect of environment on the character expression. Among all the characters high GCV and PCV were observed for canopy volume (44.92 and 51.34%), fruit weight (41.52 and 44.98%), volume of fruit (44.86 and 47.03%), pulp weight (47.61 and 49.43%), pulp: stone ratio (40.01 and 42.47%), total acidity (63.26 and 63.64%), ascorbic acid content (30.88 and 31.08%), TSS: acid ratio (61.66 and 62.36%) and fruit yield/ tree (32.47 and 33.29%) indicating the presence of high amount of genetic variability for these traits and selection for these characters would be effective because the response to selection is directly proportional to the variability present in the experimental material. Moderate estimates of GCV and PCV were observed for plant spread in E-W (19.08 and 24.46%), plant spread in N-S (18.21 and 22.44%), stem girth (22.95 and 28.56%), fruit length (26.19 and 26.75%), fruit breadth (16.46 and 17.77%), stone weight (28.08 and 29.20%), TSS (15.91 and 16.81%), total sugars (16.40 and 17.19%), reducing sugar (21.14 and 30.12%) and non-reducing sugar (18.18 and 20.53%). However, the low estimates of GCV and PCV were recorded for plant height (11.22 and 19.92%), duration of flowering (11.17 and 12.09%), duration of fruiting (13.99 and 15.70%), specific gravity (8.04 and 8.04%), total days taken to first harvesting (7.23 and 7.37%), total days taken to complete harvesting (6.01 and 6.27%), fruit set (12.74 and 13.57%), fruit drop (10.08 and 10.55%), fruit retention (15.66 and 16.37%) and number of fruit pickings (12.72 and 19.62%), depicting that the genotypes used had less genetic variability for these characters. These results are in broad conformity to earlier researchers (Gupta and Mehta 2000, Pareek *et al.* 2004, Navjot *et al.* 2009 and Dalal and Beniwal 2014) in ber.

The heritability estimate of a quantitative character is very important as phenotypic expression of a genotype may be altered by environment at various stages of its development. Heritability indicates the effectiveness with which selection for genotypes can be done on the basis of its phenotypic variation. It expresses the extent to which individual phenotypes are determined by their genotypes. The heritability estimates serve as a useful guide to the breeder because selection would be fairly easy for the characters with high heritability. Thus, there would be a close correspondence between the genotypes and phenotypes which will be attributed to a relatively smaller contribution of the environment to the phenotype. But for a character with low heritability, selection may not be effective due to the masking effect of the environment on genotypic effect. The response to selection depends upon the relative magnitude of heritable variation present in relation to the phenotypic variation. Therefore, it is desirable to partition observed variability into its heritable and non-heritable components. Burton (1952) suggested that genotypic coefficient of variation along with heritability would give a better idea about the efficiency of selection. Thus, a character with high genotypic coefficient of variation and high heritability

Table 3 Estimates of genetic variability for quality and yield attributes in ber (Pooled data)

Character	Mean	Range	Genotypic variance	Phenotypic variance	Genotypic coefficient of variation (%)	Phenotypic coefficient of variation (%)	Heritability in broad sense (%)	Genetic advance	Genetic advance as percentage of mean
TSS (%)	18.68	9.70-23.14	8.84	9.87	15.91	16.81	89.52	5.79	31.01
Total acidity (%)	0.37	0.12-1.06	0.06	0.06	63.26	63.64	98.82	0.48	129.56
Ascorbic acid (mg/100 g pulp)	133.94	50.24-200.98	1710.93	1726.50	30.88	31.02	99.10	84.82	63.33
Total sugars (%)	8.11	5.53-9.95	1.77	1.95	16.40	17.19	90.95	2.61	32.21
Reducing sugar (%)	4.40	2.21-6.78	0.87	1.76	21.14	30.12	49.27	1.35	30.57
Non-reducing sugar (%)	3.52	2.39-4.75	0.41	0.52	18.18	20.53	78.45	1.17	33.17
TSS: acid ratio	71.90	18.91-178.22	1965.32	2010.70	61.66	62.36	97.74	90.29	125.57
Fruit weight (g)	15.94	2.58-16.73	15.94	18.71	41.52	44.98	85.21	7.59	78.95
Volume of fruit (cc)	8.93	2.64-15.88	16.06	17.65	44.86	47.03	90.98	7.87	88.14
Fruit length (cm)	2.87	1.45-4.21	0.56	0.59	26.19	26.75	95.86	1.52	52.83
Fruit breadth (cm)	2.19	1.52-2.88	0.13	0.15	16.46	17.77	68.86	0.69	31.39
Stone weight (g)	0.87	0.46-1.45	0.06	0.07	28.08	29.20	92.50	0.49	55.64
Pulp weight (g)	8.59	1.81-15.58	16.73	18.03	47.61	49.43	92.79	8.12	94.49
Pulp: stone ratio	9.87	3.02-16.03	15.61	17.59	40.01	42.47	88.75	7.67	77.65
Specific gravity	1.06	0.85-1.20	0.007	0.007	8.04	8.04	99.88	0.18	16.55
Fruit yield/tree (kg)	17.82	5.77-26.43	33.48	35.42	32.47	33.29	94.53	11.59	65.02

will be more valuable in selection programme. In present investigation, high heritability was observed for specific gravity (99.88%), ascorbic acid (99.10%), total acidity (98.82%), TSS: acid ratio (97.74%), total days taken to first harvesting (96.19%), fruit length (95.86%), fruit yield/ tree (94.53%), pulp weight (92.79%), stone weight (92.50%), total days taken to complete harvesting (92.00%), fruit retention (91.49%), fruit drop (91.31%), volume of fruit (90.98%), total sugars (90.95%), TSS (89.52%), pulp: stone ratio (88.75%), fruit set (88.19%), duration of flowering (85.26%) and fruit weight (85.21%). All the traits exhibited more than 80% heritability. The moderate heritability was noticed for duration of fruiting (79.48%), non-reducing sugar (78.45%), canopy volume (76.58%), fruit breadth (68.86%), plant spread in N-S (65.89%), stem girth (64.65%) and plant spread in E-W (60.82%). High heritability in broad sense indicated that large proportion of phenotypic variance was attributable to the genotypic variance and that differences among the genotypic were hereditary and showed that the above mentioned traits were less influenced by the environment. High heritability in ber was also reported for all the above traits by Gupta and Mehta (2000), Pareek *et al.* (2004), Navjot *et al.* (2009), Islam *et al.* (2010) and Dalal and Beniwal (2014). Low heritability values have been reported by Manohar *et al.* (1986) and Gupta and Mehta (2000).

Heritability estimate alone do not provide reliable information about the gene action governing the expression of a particular character and also this does not provide the information of the amount of genetic progress that would result from the selection of the best individuals. Johnson *et al.* (1955) had pointed out that the heritability estimates along with genetic advances were more useful than heritability estimates alone in predicting the response to selection. High genetic advance was observed for total acidity (129.56%), TSS: acid ratio (125.57%), pulp weight (94.49%), volume of fruit (88.14%), canopy volume (80.98%), stem girth (80.98%), duration of flowering (80.98%), fruit weight (78.95%), pulp: stone ratio (77.65%), fruit yield/tree (65.02%), ascorbic acid content (63.33%), stone weight (55.64%) and fruit length (52.83%). Moderate genetic advance was recorded for non-reducing sugar (33.17%), total sugars (32.21%), fruit breadth (31.39%), TSS (31.01%), fruit retention (30.86%), plant spread in E-W (30.65%), reducing sugar (30.57%), plant spread in N-S (30.46%) and duration of fruiting (25.70%). The characters, viz. total days taken to complete harvesting (11.88%), total days taken to first harvesting (14.61%), plant height (13.02%), specific gravity (16.55%), number of fruit pickings (16.99%), fruit drop (19.84%) and fruit set (24.65%) had low genetic advance. Gupta and Mehta (2000), Pareek *et al.* (2004), Navjot *et al.* (2009), Islam *et al.* (2010) and Dalal and Beniwal (2014)

have also reported more or less similar results in ber.

The genetic advance is a useful indicator of the progress that can be expected as result of exercising selection on the pertinent population. Heritability in conjunction with genetic advance would give a more reliable index of selection value (Johnson *et al.* 1955). Relative comparison of heritability along with genetic advance as per cent of mean over the characters indicated that characters, viz. duration of flowering, fruit weight, volume of fruit, fruit length, stone weight, pulp weight, pulp: stone ratio, total acidity, ascorbic acid, TSS: acid ratio and fruit yield/ tree had high heritability estimates along with high genetic advance as per cent of mean. High heritability coupled with high genetic advance recorded for various traits in the present study indicates the presence of additive gene action and these traits are likely to respond better to selection. Panse and Sukhatme (1961) suggested that the genotypic variations for such characters is probably due to high additive gene effects and are least influenced by the environment. The phenotypic selection based on such a character is likely to be more effective for improvement and hence, these characters provide good opportunity for further breeding programme using simple breeding methods.

In respect of the traits such as fruit retention, TSS and total sugars had high heritability and associated with moderate genetic advance which can be improved by intermating superior genotypes of segregating population developed from combination breeding. High heritability along with lower genetic advance for the traits like specific gravity, total days taken to first harvesting, total days taken to complete harvesting, fruit set and fruit drop may be attributed to the non-additive gene effects and this may be improved through hybridization. Moderate heritability in combination with moderate genetic advance was observed for plant spread (E-W), plant spread (N-S), duration of fruiting and non-reducing sugar, whereas moderate heritability in combination with high genetic advance was observed for canopy volume and stem girth in pooled data. These findings are in close conformity to those of Gupta and Mehta (2000), Pareek *et al.* (2004), Navjot *et al.* (2009), Islam *et al.* (2010) and Dalal and Beniwal (2014) in ber.

Thus, high heritability along with high genetic advance as per cent of mean was observed for duration of flowering, fruit weight, volume of fruit, fruit length, stone weight, pulp weight, pulp: stone ratio, total acidity, ascorbic acid, TSS: acid ratio and fruit yield/tree in pooled data. In this condition selection will be more effective for these characters. However, low heritability and low genetic gain was reported for plant height therefore, selection in this character would not be much effective.

Based on the findings in this study, it is concluded that twelve characters, viz. fruit weight, volume of fruit, pulp weight, pulp: stone ratio, total acidity, ascorbic acid, TSS: acid ratio and fruit yield/ tree could be used as good criteria for selection in the ber improvement in semi-arid conditions because these characters had high GCV, heritability estimate and genetic advance as percent of the mean. The genotypes *viz*., Gola, Katha, Tikadi had maximum average value of different growth, yield and quality traits which can be used as potential parents in hybridization programme.

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