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Impact of polyploidy on morphological and physiological parameters in ber

Rakesh Bhargava*, Anil Kumar Shukla, B.D. Sharma and O.P. Awasthi
Central Institute for Arid Horticulture, Bikaner-334 006

Abstract

Polyploidy has played a pivotal role in the evolution of plants and production of genetic variability. Although, the impact of polyploidy on plant vegetative, floral and fruit characters have been documented indepth, but impact on physiological efficiency has been studied rarely. The present attempt was to screen the polyploid taxa on the basis of physiological parameters in a polyploid sense of ber (*Ziziphus mauritiana* Lam.). Our results demonstrated that in this species, the polyploidy has shown variable effect in different cultivars. In cv. Illaichi it reduced the physiological efficiency but in cv. Gola it maintained at par.

Key words: *Ziziphus mauritiana, photosynthetic rate, polyploidy*

Introduction

Ber (*Ziziphus mauritiana* Lam.) also known as poor man's fruit and desert apple is an important fruit crop of arid and semi-arid ecosystem. The plants are drought hardy and hence can produce economic yields under low moisture availability. The fruits are rich in vitamins (C,A and B-Complex) and minerals. Since cultivation of ber requires less care hence, the trees can be grown in resource poor areas. A rich genetic diversity of this crop has been collected and maintained at National Repository of CIAH, Bikaner (Shukla *et al.*, 2004a).

The analysis of karyotype of ber has revealed that the genus has the basis number x = 12 (Bowden, 1945; Khoshoo and Singh, 1963; Nehra *et al.*, 1983). Among the genetic variability available in India Khoshoo and Singh (1963) reported 2n =48 in about 33 genotypes. Similarly, Nehra *et al.* (1983) reported the chromosome number to be 96 in cv. Illaichi, Gola and Bordi and 2n =48 in cv. Umran.

Despite the fact that the cultivars of *Z. mauritiana* demonstrate variable chromosome numbers. Yet the attempts to study the impact of this on plant morphometry and physiological parameters is scanty. Accordingly, during the course of present study, an attempt was made to evaluate the effect of polyploidy in 4 cultivars of ber differing in their chromosome numbers.

Material and methods

The studies were undertaken on well established trees of 4 cultivars viz. Umran, Seb, Gola and Illaichi. The plants were 7 years old and in bearing stage. The normal, uniform cultural practices were adopted in all plants. The data on plant morphometry was recorded during the month of December. The plant height, spread were recorded with the help of measuring pole. The leaf dimensions were recorded in centimeter.

The observations on rate of photosynthesis and associated parameters were measured, on well established plants of cultivars under study. The observations were recorded during fruiting season in the forenoon using LI-6200 Infra Red Gas Analyzer. The values of carboxylation efficiency and water use efficiency were measured by using the method as described by Das *et al.* (1999).

Results and discussion

Impact of polyploidy on vegetative parameters

The influence of polyploidy on plant morphometry was earlier studied in a variety of plants (Stebbins, 1971; Bose and Flory, 1965; Raghuvanshi and Pathak, 1975; Karihaloo, 1977 and Singh, 1990).

During the course of present study, two cultivars having genomic constituents as tetraploid (Umran and Seb) and two with genomic constitutent as Octaploid (Gola and Illaichi) were studied for the impact of polyploidy on vegetative characters. The data thus obtained are presented in Table 1. Perusal of table reveals that the plants of Gola demonstrated the maximum magnitude in terms of vegetative characters. This is illustrated by the fact that the plants of Gola are 4.58 m tall with stem diameter of 16.8 cm, having plant canopy spread of 5.3 m x 5.2 m and leaf size of 6.9 cm x 4.8 cm. On the contrary, Umran (4x) demonstrate the lowest magnitude with the plant height of 2.60 m, plant spread of 2.3 m x 2.8 m, stem diameter of 8.6 cm

*Corresponding author's E-mail:
rbciah@yahoo.com

Table 1. Morphological parameters in polyploid series in ber

Variety	Pl. ht. (m)	Pl. spread (m)	Stem dia. (cm)	Leaf size (cm)	Pruned wood wt. (kg)
Umran (4x)	2.60	2.3 x 2.8	8.6	7.3 x 3.4	14.0
Seb (4x)	4.3	4.0 x 4.4	12.50	6.9 x 4.5	13.0
Gola (8x)	4.58	5.3 x 5.2	16.8	6.9 x 4.8	34.0
Illachi (8x)	3.50	2.8 x 3.0	16.8	7.5 x 5.0	08

and leaf size of 7.3 cm x 3.4 cm. The other two cultivars showed intermediate values. Thus, our study reveals that polyploidy showed differential response in terms of its effect on plant vegetative parameters. In case of Gola it enhanced the magnitude but in case of Illaichi it reduced the magnitude with respect to Seb but shows improvement over Umran (4x). The results are in line with those reported by Chaudhry (1996) who reported that tetraploidy increases vegetative growth.

That the plants shows differential response in terms of polyploidy has been demonstrated earlier also. In case of *Naricissus tazelta*, similar variations has been reported among different cultivars (Bhargava *et al.*, 1985).

The pruned wood weight was also estimated in each case which reflects the quantum of vegetative growth achieved during season. It was demonstrated that Illaichi (8x) had the lowest pruned wood weight (8 kg.). The tetraploid types Umran and Seb had 14.0 and 13.0 kg respectively. But Gola (8x) demonstrated highest pruned wood weight (34.0 kg). The results thus reveal that in cultivar Gola (8x) the polyploidy has enchanced the magnitute of vegetative parameters but in Illaichi it has depressed the same.

Impact of polyploidy on fruit characters

The impact of polyploidy on fruit characters were also studied during the course of present study. The data thus generated is presented in Table 2. Perusal of data reveals that, as in case of vegetative parameters, with respect to fruit characters also, the cultivars showed variable response with the imposition of polyploidy.

Perusal of data in Table 2 reveals that Seb (4x) showed the minimum length but highest diameter. Whereas, Umran (4x) showed maximum length and moderate diameter. On the contrary, the fruit of Gola (8x) and Illaichi (8x) demonstrated smaller fruit size as compared to Umran. This illustrates that in ber, the polyploidy has reduced the size

Table 2. Fruit characters in polyploid series of ber

Variety	Fruit size (cm)	Fruit wt. (g)	Stone wt (g)	TSS (°Brix)	Yield (kg/ tree)
Umran (4x)	5.3 x 3.8	50	1.10	20.00	42.0
Seb (4x)	2.8 x 4.2	42.0	1.95	21.0	32.0
Gola (8x)	4.0 x 3.7	35.0	1.9	22.50	35.0
Illachi (8x)	3.1 x 3.1	8.0	0.7	24.0	18.0

of fruit. Perusal of data on fruit weight and stone weight also demonstrated that imposition of polyploidy has reduced the fruit and stone weight. This is illustrated by the fact that the average fruit weight of Gola (8x) and Illaichi (8x) is only 35.0g and 8.0 g respectively, whereas that of Umran (4x) and Seb (4x) was 50.0g and 42.0g, respectively. Similar, trend was also observed with respect to stone weight and fruit yield (Table 2). Similar results has also been shown by Singh (1990) and Pathak and Pathak (1993) where it has been demonstrated that polyploid reduces the vegetative and fruit characters.

Although, the polyploidy has reduced the morphometric parameters in ber, but it has further improved the TSS content of ber fruits. This is illustrated by the fact that TSS of Umran (4x) and Seb (4x) was 20% and 21% respectively whereas in octaploid taxa Gola (8x) and Illaichi (8x) it was 22.5% and 24% respectively.

Impact of polyploidy on physiological parameters

Some physiological parameters were also investigated in these polyploid taxa which are presented in Table 3. Perusal of data presented in Table 3 reveals that the cultivars showed variable response with respect to polyploidy.

In case of cv. Illaichi (8x) the photosynthetic rate was found to be lowest (0.935 mg CO_2 $m^{-2}s^{-1}$) as compared of other cultivars. Similarly, the water use efficiency (1.23) was moderate and carboxylation efficiency (0.09) was also reduced as compared to tetraploid taxon. The cultivar also recorded lowest RWC (64.59%) and a higher rate of transpiration (1.143 mg H_2O $m^{-2}s^{-1}$). All these parameters reveals that cv. Illaichi has poor photosynthetic rate which reflects on the low yield of the cultivar (18 kg/tree).

In contrast to above cv. Gola (8x) is at par with Umran (4x) in the rate of photosynthesis, has lowest transpiration rate (0.666 mg H_2O/m^2 s^{-1}.), maintain high RWC (91.32%) but has poor carboxylation efficiency (0.097).

The cv. Seb (4x) had the highest photosynthetic rate

Table 3. Physiological parameters in polyploid series of ber

Variety	Photosynthesis rate (mg CO_2 $m^{-2}s^{-1}$)	Transpiration rate (mg $H_2Om^{-2}s^{-1}$)	Stomatal conductance (cm s^{-1})	WUE	Carboxylation efficiency	RWC (%)
Umran (4x)	1.087	1.130	2.259	0.955	0.087	88.39
Seb (4x)	1.468	0.739	2.691	1.980	0.164	76.43
Gola (8x)	1.057	0.666	3.867	1.587	0.097	91.32
Illachi (8x)	0.935	1.143	2.585	1.234	0.090	64.59

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Variation and association of ber Genotypes for powdery mildew and contributing traits

A.K. Godara* and P.L. Saran
Department of Horticulture, CCS Haryana Agricultural University, Hisar–125 0001

Abstract

Thirty-five genotypes of ber collected from different places were studied for their variance, heritability, genetic advance and correlation coefficient for various traits. The PCV was higher than GCV, as powdery mildew exhibited highest PCV (52.76) and GCV (41.72) while highest heritability observed for fruit length (99.01). High Genetic advance as percent mean was observed for powdery mildew (96.09). Powdery mildew also has highly significant and positive correlation with fruit breadth (0.3483). So powdery mildew, stone breadth stone weight, fruit weight, etc., should be given due consideration while performing selection for jujube improvement.

Key words: *Variability, heritability, correlation, powdery mildew, Ziziphus mauritiana*

Introduction

In India, there is rich biodiversity of Indian jujube (*Ziziphus mauritiana* Lam.). It is one of the most ancient and common fruits of India. It belongs to buckthorny family (Rhamnaceae) and is grown throughout the tropical, sub-tropical and arid regions of the world but it is most popular fruit of arid region. The northern India is unique due to its typical climatic conditions. Indian jujube is quite popular due to low cost of cultivation, wide adaptability, ability to withstand drought and good economic returns. In its cultivation, powdery mildew caused by *Oidium eryriphoides* f. zhizhyphi Fr, is a serious problem leading to varying degree of losses in all the ber growing regions of India. All the cultivars with large fruit size succumb to this disease under high input management conditions, sometimes rendering the entire produce unmarketable. Small fruits are reported to be less susceptible (Pardeep and Jambhale, 2001).

The possibility of improvement in any crop is measured by variability available in the crop. Wider the genetic variability, greater the chances of improvement with respect to different desirable traits. Knowledge of association between powdery mildew and contributing traits of crop is of paramount importance in selection and hybridization programme particularly for Indian conditions. Keeping this in view, the present investigations were undertaken to know the association between powdery mildew and other traits and among them in Indian jujube thus an effort was made to identify the sources of resistance to powdery mildew for initiating resistance or tolerance breeding programme.

***Corresponding author's E-mail :**
Sr. Scientist, CCS, Haryana Agricultural University, Hisar

Materials and methods

Thirty-five genotypes of *Ziziphus mauritiana* were studied for ten morphological traits. The selected genotypes planted at 8 m x 8 m spacing in RBD with three representative plants of twenty-seven year age, having uniform training and pruning budded on *Ziziphyus rotundifolia* rootstock constituted as experimental plant material.

The observations were recorded for ten traits viz., powdery mildew, leaf length, leaf breadth, leaf area, fruit weight, fruit length, fruit breadth, stone weight, stone length, and stone breadth during 2005-2006. The statistical analysis for estimating the genotypic and phenotypic coefficients of variation, heritability in broad sense, genetic advance as percentage of mean were done as suggested by Burton (1952). Phenotypic and genotypic correlations were calculated as per Fisher (1954).

Results and discussion

The mean sum of squares due to genotypes were highly significant (at 1% level) for all the traits (Table 1) which indicated that sufficient amount of variability was present in the germplasm for all the traits. The PCV was higher than GCV (Table 2). Powdery mildew exhibited highest PCV (53.76) and GCV (41.72), which were followed by stone weight (34.44 g), fruit weight (30.76 g) and leaf

Table 1. Mean sum of square obtained from the analysis of variance for various traits in ber genotypes

Sr. No.	Source of replication	d.f.	Powdery mildew	Leaf length	Leaf breadth	Leaf area	Fruit weight	Fruit length	Fruit breadth	Stone weight	Stone length	Stone breadth
1.	Replication	2	50.25	0.53	1.5	10.87	0.47	0.01	0.01	0.00	0.17	0.01
2.	Treatment	34	1490.42	213.24	2.17	197.30	52.97	2.17	0.32	0.16	0.93	0.06
3.	Error	68	72.12	22.73	0.14	6.83	0.61	0.01	0.00	0.00	0.02	0.00
	CV (%)		19.56	6.28	7.57	9.28	5.64	2.34	1.94	9.93	5.72	8.08

Table 2. Mean range, coefficient of variation (genotypic and phenotypic), heritability and genetic advance for powdery mildew and its contributing traits in ber genotypes

Sr. No.	Traits	Mean ±SE	Range	Coefficient of variation		Heritability (%)	Genetic advance as % of mean
				Phenotypic	Genotypic		
1.	Powdery mildew	14.42±4.90	10.67-84.33	53.76	41.72	86.76	96.09
2.	Leaf length	9.21±0.33	6.73-13.83	16.52	2.68	85.55	29.12
3.	Leaf breadth	4.86±0.21	3.23-6.90	18.58	1.55	83.40	31.93
4.	Leaf area	28.13±1.51	14.83-51.99	29.79	15.60	90.29	55.40
5.	Fruit weight	13.82±0.45	3.92-20.88	30.76	8.46	96.64	61.23
6.	Fruit length	3.78±0.50	1.94-5.42	22.57	1.74	99.01	46.03
7.	Fruit breadth	2.67±0.03	1.93-3.30	12.25	0.66	97.50	24.60
8.	Stone weight	0.69±0.04	0.20-1.21	34.44	0.46	91.69	65.06
9.	Stone length	2.34±0.07	1.06-3.15	24.83	1.11	94.70	48.44
10.	Stone breadth	0.82±0.04	0.53-1.14	19.03	0.26	81.98	32.14

Table 3. Phenotypic and genotypic correlation coefficient among various traits

Sr. No.	Leaf length (cm)	Leaf breadth (cm)	Leaf area (cm)	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Stone weight (g)	Stone length (cm)	Stone breadth (c
1.	-0.2555	0.0734	-0.0857	0.2463	-0.1453	0.3483*	0.1552	-0.2253	0.1249
2.		0.5622	0.8300**	0.0042	0.1457	-0.0864	-0.0062	0.1718	-0.1606
3.				-0.0591	0.1414	-0.1781	-0.1840	0.1991	-0.3186
4.					0.7002**	0.8968**	0.6176**	0.6105**	0.3846*
5.						0.3622	0.4063	0.9636**	-0.0982
6.							0.6767*	0.2667	0.6620**
7.								0.4080*	0.8455**
8.									-0.1119
9.									-
10.									

area (29.79 cm²). This indicated that there was sufficient amount of variability present among genotypes for all these traits. Considerable genetic variability for yield and contributing traits were also reported in Indian jujube by Bisla and Daulta (1986). Heritability estimates were high for all the traits. The maximum heritability was recorded for fruit length (99.01%) while minimum for stone breadth (81.98%). The highest expected genetic advance as per cent of mean was observed for powdery mildew (96.09) followed by stone weight (65.06) and the lowest for fruit breadth (26.60). High heritability coupled with high genetic advance became more useful in selection were also reported by Bisla and Daulta (1986) and Saran *et al.* (2007a) in ber genotypes.

The correlation coefficients estimated in all the possible ways among the different traits are presented in Table 3. The values of genotypic correlation coefficient were higher than phenotypic correlation coefficient for all the traits. Powdery mildew had positive and significant correlation with fruit breadth (0.3483). Leaf length showed positive correlation with leaf area (0.830). Leaf breadth also showed positive correlation with leaf area (0.9648). The fruit weight showed high positive correlation with fruit length (0.7002), fruit breadth (0.8968), stone weight (0.6176) and stone length (0.6105). Fruit length has positive correlation with stone length (0.9636) and fruit breadth also has positive

correlation with stone weight (0.6767) and stone breadth (0.6620) while stone weight showed positive correlation with stone length (0.4080) and stone breadth (0.8455). Significant correlation of these traits suggests the scope of direct and indirect effective selection for further improvement for powdery mildew as well as yield of jujube crop. Similar reports on yield and quality of ber genotypes were also reported by Saran *et al.* (2007b) and Bisla and Daulta (1986). They observed that the significant positive correlation of these traits with fruit yield was due to fruit weight.

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