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Genetic diversity in mahua (*Bassia latifolia*) under semi-arid ecosystem of Gujarat*

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Mahua (*Bassia latifolia* Roxb.) is an economically multipurpose tree of the family Sapotaceae. The tree is well known to the rural folk since ages in India. It is very hardy and thrives well on rocky, gravelly, saline and sodic soils, even in pockets of soil between crevices of barren rock (Singh 1998). Its flowers, fruits and seed oil are consumed in various ways. The corolla commonly called *mahua* flower is a rich source of sugar containing appreciable amount of vitamins and minerals and may be used for preparation of distilled liquors and potable spirits (Singh *et al.* 1999). The fruit pulp may be utilized as source of sugar for alcoholic fermentation. The oil obtained from kernel is used for edible purpose and permitted for preparation of vegetable oil. *Mahua* oil is used in manufacture of soap, lubricating grease, fatty alcohols and candles. Cake obtained after extraction of oil is used as manure and has insecticidal properties. In tribal belt of Gujarat, *mahua* trees are found growing naturally as stray plantation on wasteland. It is highly heterozygous, cross-pollinated fruit crop and as such seedlings exhibit a wide range of variations, which aids in the selection of the superior desirable genotypes. Due to cross pollination and predomination of seed propagation over a long period of time, it gives immense opportunity to locate elite trees having positive horticultural traits. Wide variations were observed in sweetness, acidity, size, shape and bearing habits in Mahua under Uttar Pradesh and Gujarat conditions (Singh *et al.*1999 and Anonymous 2002). Considerable genetic diversity under various agro-climatic conditions in different under utilized fruits like tamarind, *jamun* has also been reported (Keskar *et al.* 1989a, Keskar *et al.* 1989 b, Karale *et al.* 1999 and Devi *et al.* 2002). Present investigation was carried out to find out variability in flowering, fruiting and fruit quality attributes of different genotypes so that the valuable germplasm could be protected from being eroded and at the same time its utilization is also maximized under crop improvement programme.

The *mahua* trees are found scattered throughout Gujarat from cultivable land to waste lands. An extensive survey was made in Panchamahal district and adjoining areas during the year 2003 and 2004 to identify elite types of germplasm among its population. Twenty promising genotypes from different locations and age group were selected which had fairly wide spectrum of variability of various characters and they were considered as experimental materials. The observations were recorded on tree characters, flowering, fruiting and fruit quality attributes for two consecutive years and pooled data are presented in the Tables 1,2. Twenty healthy fascicles from each tree were randomly selected to record number of flowers and fruits per fascicle. The ripe fruits differing in shape, size and appearance were collected to study the variability in physico-chemical attributes. The trees were free from pests and diseases. Healthy fruits were harvested and experiment was laid out in completely randomized design with 3 replications. Total soluble solids and titratable acidity were determined by standard methods. Protein, minerals, Vitamin C and sugars were analyzed by the method advocated by AOAC 1980. Oil content in Mahua kernel was determined by the method described by Rangana 1986.

Perusal of the data, collected from the studies on the genetic diversity of *mahua* in Gujarat showed that the different trees varied widely in tree characters, flowering, fruiting and fruit quality attributes. Maximum tree height (18.50 m), trunk girth (3.60 m) and tree spread (18.50 and 17.50) were recorded in 'MH 4', 'MH 18' and 'MH 16', respectively (Table 1). Age of the tree ranged from 24 to 45 years in different genotypes. Peak period of flowering was earliest (first week of March) in 'MH 1', 'MH 4', 'MH 5' while it was delayed in 'MH 6' (second week of April). There was marked variation in average number of flowers/fascicle in most of the genotypes and 'MH 2' recorded maximum number of flowers/fascicle (45) followed by 'MH 4', 'MH 10' and 'MH 14' while it was found least in 'MH 15'. Maximum number of fruits per fascicle was noted in 'MH 2' (8.00) followed by 'MH 4', 'MH 10' and 'MH 3' (Table 1). Singh (1998) recorded wide range of variability in *mahua* genotypes under Uttar Pradesh conditions and recorded 66.00,54.60, 64.30 and 78.50 flowers per fascicle in collection number 2,4, and 8 respectively. The leaf area (cm^2) varied from 70.00–128.00 cm^2 and being 'MH 8' at the top followed by 'MH 10', 'MH 7', 'MH 4' and 'MH 3'. Early ripening, i e second

*Short note

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Table 1 Variability in tree characters, flowering, fruiting and fruit yield attributes

Genotype	Tree height (m)	Trunk girth (m)	Tree spread (m)		Tree age (year)	Flowering time	Flowers/Fruits/ fascicle	fascicle	Bearing habit	Leaf area (cm^2)	Harvesting time	Dry flower yield (kg/plant)	Fruit yield (kg/ plant)
			E–W	N–S									
'MH 1'	14.23	2.10	10.50	11.20	30	1st week March	27.50	6.00	Regular	90.00	2nd week May	30.50	50
'MH 2'	18.50	3.20	18.20	16.12	35	2nd week March	45.00	8.00	Regular	110.00	3rd week May	46.00	82
'MH 3'	17.30	2.71	15.30	14.50	36	4th week March	24.00	6.50	Regular	114.00	1st week June	38.50	60
'MH 4'	18.50	3.20	15.12	16.34	37	1st week March	34.00	7.00	Regular	115.0	4th week May	42.00	75
'MH 5'	13.20	1.80	9.20	10.50	30	1st week March	20.00	5.00	Regular	85.00	2nd week May	38.00	50
'MH 6'	14.50	2.50	13.20	15.00	28	2nd week April	18.00	5.00	Regular	70.00	4th week May	35.00	45
'MH 7'	17.00	1.80	12.13	13.10	26	2nd week March	27.50	4.00	Regular	119.00	4th week May	36.00	48
'MH 8'	16.50	2.50	12.60	11.40	24	3rd week March	32.00	5.00	Regular	128.00	2nd week May	35.80	47
'MH 9'	15.00	2.10	10.00	11.50	25	1st week April	30.50	6.00	Regular	115.00	4th week May	32.00	42
'MH 10'	14.50	2.60	14.50	13.10	28	2nd week March	33.50	7.00	Regular	120.00	2nd week May	38.00	78.50
'MH 11'	13.80	2.30	14	13.50	32	4th week March	34.0	4.00	Regular	98.00	4th week May	30.00	35
'MH 12'	13.50	2.70	13	14.50	31	2nd week March	18.50	5.00	Regular	92.00	2nd week May	32.00	53.50
'MH 13'	14.50	2.40	12	11.00	30	3rd week March	20.00	3.00	Regular	110.20	4th week May	38.50	55
'MH 14'	14.80	2.53	10.50	12.00	35.50	2nd week March	32.00	5.00	Regular	112.00	2nd week May	45.00	80
'MH 15'	12.00	2.10	15.90	13.20	32	2nd week March	17.50	4.00	Regular	89.35	3rd week May	37.00	52
'MH 16'	16.00	3.50	18.50	17.50	45	3rd week March	18.00	3.50	Regular	89.50	4th week May	43.00	70
'MH 17'	17.20	3.40	16.50	14.60	40	2nd week March	20.50	3.00	Regular	102.00	3rd week May	40.00	68
'MH 18'	16.50	3.60	15.50	16.20	42	3rd week March	25.50	4.00	Regular	110.24	4th week May	40.00	72
'MH 19'	17.00	2.40	13.20	14.19	38	1st week April	23.50	4.50	Regular	113.30	1st week June	42.00	60
'MH 20'	14.00	2.90	14.00	15.50	36	4th week March	26.00	4.00	Regular	112.30	3rd week May	38.00	63
CD ($P = 0.05$)							4.44	0.72		5.12			

E–W, East–West; N–S, north–south

Table 2 Variability in physico- chemical attributes of *mahua* flowers

Genotype	Flower weight (g)	Juice (%)	Pomace (%)	Stamen (%)	TSS (%)	Acidity (%)	Total sugar (%)	Reducing sugar (%)	Vitamin C (mg/100g)
'MH 1'	2.30	67.00	32.20	0.80	25.00	0.09	22.11	18.50	58.00
'MH 2'	2.40	69.00	30.30	0.70	26.10	0.08	23.14	19.60	62.50
'MH 3'	2.30	64.10	35.30	0.60	27.00	0.10	24.14	20.00	61.60
'MH 4'	2.32	68.50	30.60	0.90	27.80	0.11	24.24	20.11	64.00
'MH 5'	2.11	61.60	37.69	0.81	24.00	0.12	21.09	18.11	53.00
'MH 6'	2.13	60.90	38.84	0.86	27.50	013	20.00	17.50	52.00
'MH 7'	1.91	62.00	37.17	0.83	24.00	0.10	21.11	18.00	44.30
'MH 8'	1.90	68.52	30.57	0.93	26.00	0.91	23.00	19.60	42.90
'MH 9'	1.89	66.00	33.06	0.94	26.00	0.94	23.11	16.64	46.00
'MH 10'	2.29	65.00	34.07	0.93	26.37	0.98	23.17	19.49	59.00
'MH 11'	2.26	60.60	38.46	0.94	25.00	1.10	22.19	19.00	44.00
'MH 12'	2.19	63.00	36.07	0.93	24.11	1.08	20.89	17.89	43.00
'MH 13'	2.10	65.0	34.04	0.96	26.00	1.07	21.97	18.30	49.30
'MH 14'	2.24	66.00	33.08	0.92	25.00	1.08	21.00	18.40	59.00
'MH 15'	2.16	63.25	35.86	0.89	25.50	1.12	21.14	18.50	56.40
'MH 16'	2.25	62.50	36.62	0.88	25.00	1.13	21.00	18.11	58.00
'MH 17'	2.16	63.11	36.06	0.83	26.00	1.10	22.10	19.00	59.00
'MH 18'	2.19	65.00	34.07	0.93	24.00	1.07	21.34	18.79	5613
'MH 19'	2.00	61.00	38.06	0.94	24.90	1.06	20.99	17.94	56.12
'MH 20'	2.10	60.00	39.02	0.98	26.10	1.07	23.00	20.00	59.14
CD ($P = 0.05$)	0.11	1.39	1.92	NS	0.60	0.03	0.54	0.51	1.39

week of May was recorded in 'MH 1', 'MH 5', 'MH 8', 'MH 10', 'MH 12' and 'MH 14' while it was noted late (first week of June) in 'MH 3' and 'MH 19'. Dry flower yield ranged from 28–46 kg and it was found to be highest in 'MH 2' (46 kg/ plant) followed by 'MH 4', 'MH 19', 'MH 14', 'MH 13' and 'MH 3'. Wide range of variability was observed in fruit yield

Table 3 Variability in physico- chemical attributes of *mahua* fruits and kernels

Genotype	Fruit weight (g)	Husk weight (g)	Husk (%)	Seed weight (g)	Seed (%)	TSS (%)	Acidity (%)	Total sugar (%)	Reducing sugar (%)	Vitamin C (mg/100 g)	Kernel weight (g)	Kernel (%)	Shell weight (g)	Shell (%)	Oil (%)	Protein (%)	Minerals (%)
'MH 1'	15.00	9.50	63.33	5.50	36.66	13.00	0.08	11.14	8.20	45.00	4.20	76.36	1.30	23.64	41.00	20.00	4.11
'MH 2'	34.50	20.00	57.97	14.50	42.03	15.00	0.09	13.13	10.12	66.00	12.10	83.45	2.38	16.55	46.50	24.00	4.90
'MH 3'	22.00	14.50	65.90	7.50	34.09	11.50	0.11	9.24	7.19	48.50	5.14	68.53	2.36	31.47	43.00	21.00	4.15
'MH 4'	32.00	18.00	56.25	14.00	43.75	14.50	0.12	11.18	8.56	59.40	12.00	85.71	2.00	14.29	45.00	23.00	4.68
'MH 5'	18.00	11.00	61.00	7.00	38.88	11.00	0.09	9.30	7.11	50.11	5.10	72.86	1.90	27.40	43.00	22.10	3.93
'MH 6'	25.00	14.50	58.00	10.50	42.00	12.00	0.09	9.43	7.20	52.00	8.13	77.44	2.37	22.56	40.00	21.30	3.98
'MH 7'	26.00	15.00	57.69	11.00	42.30	13.00	0.08	10.19	8.10	56.00	9.00	81.81	2.00	18.19	42.00	20.14	3.90
'MH 8'	28.00	14.37	51.32	13.63	48.67	12.10	0.08	9.45	7.03	45.00	11.14	81.73	2.46	18.27	43.50	21.13	4.11
'MH 9'	20.00	11.10	55.50	8.90	44.50	13.14	0.08	11.03	8.14	61.00	7.11	79.88	1.79	20.12	44.80	22.30	4.09
'MH 10'	30.50	17.00	55.73	13.50	44.27	14.00	0.09	11.43	8.43	48.30	11.00	81.48	2.50	18.52	46.00	24.10	4.83
'MH 11'	22.00	12.20	56.36	9.60	43.63	13.00	0.12	10.11	8.00	44.11	7.14	74.38	2.46	25.62	41.90	23.00	4.15
'MH 12'	24.00	13.00	54.16	11.00	45.83	13.14	0.11	10.17	8.04	48.00	9.03	82.09	1.97	17.91	42.00	21.30	4.30
'MH 13'	26.00	14.00	53.84	12.00	46.15	12.94	0.13	9.76	7.80	46.00	9.43	78.58	2.57	21.42	44.00	20.11	3.93
'MH 14'	29.00	16.30	56.20	12.70	43.80	14.10	0.08	11.78	9.04	60.40	9.53	74.92	3.17	25.08	45.50	23.50	4.73
'MH 15'	22.50	12.00	53.33	10.50	46.66	13.11	0.09	11.10	8.94	45.11	8.73	83.14	1.77	16.86	41.50	20.80	3.94
'MH 16'	20.10	11.00	54.72	9.10	45.27	13.41	0.11	11.21	8.45	44.00	7.14	78.46	1.96	21.54	42.00	22.30	3.95
'MH 17'	21.00	12.00	57.14	9.00	42.86	12.00	0.12	9.08	7.00	43.00	7.10	78.88	1.90	21.12	43.00	23.10	4.09
'MH 18'	18.00	10.10	56.11	7.90	43.89	12.19	0.13	9.13	7.03	52.55	5.64	71.39	2.26	28.61	44.50	23.09	4.14
'MH 19'	18.50	10.00	54.05	8.50	45.95	12.00	0.11	9.00	7.00	56.41	6.19	72.82	2.31	27.18	45.10	22.01	4.20
'MH 20'	20.50	11.60	56.58	8.90	43.42	13.00	0.09	10.13	7.53	55.00	6.50	73.03	2.40	26.97	44.50	20.11	3.94
CD ($P = 0.05$)	2.16	1.34	1.79	1.36	1.11	0.53	NS	0.64	0.68	2.67	1.13	0.56	0.32	1.38	1.30	0.68	0.43

per plant. It was found to be highest in 'MH 2' (82 kg/plant) followed by 'MH 14', 'MH 4', 'MH 10' and 'MH 16', while lowest fruit yield was recorded in 'MH 11'. Singh (1998) recorded the variability in fruit yield attributes on 5–7 year-old grafted plants of *mahua* under Uttar Pradesh conditions. Variation in soil and climatic conditions might have caused wide range of variability in different genotypes. Karale *et al.* (1999), Keskar *et al.* 1989, Devi *et al.* 2002, Mitra 1998, Kundu *et al.* 2001, Pareek and Awasthi, 2002, Maiti and Mitra 2002 and Sakhyan *et al.* 2004 observed existence of variability in under utilized fruits like tamarind, *jamun*, jackfruit and sea buckthorn under various agro-climatic conditions.

Variability recorded in physical and biochemical characters in Mahua flowers has been presented in Table 2. The flower juice was found to be highest (69%) in 'MH 2' followed by 'MH 4', 'MH 8' and 'MH 9'.While, total soluble solids, total sugar, reducing sugar and vitamin C content of flowers was the highest in 'MH 4' followed by 'MH 2', 'MH 3', 'MH 10' and 'MH 14'. Weight of *mahua* fruit was maximum in 'MH 2' followed by 'MH 4', 'MH 10', 'MH 1 4' and 'MH 8' while least fruit weight was recorded in 'MH 1'. The fruits of 'MH 3' recorded maximum husk per cent (65.90) and that of 'MH 8' the lowest (51.32). The seed percent was found maximum in MH 8 followed by 'MH 15', 'MH 13', 'MH 12' and 'MH 16'. The total soluble solids, total sugar and vitamin C contents of the fruits were maximum in 'MH 2' followed by 'MH 9', 'MH 4' and 'MH 14'. Singh *et al.* (1999) and Annonymous (2002) have also recorded the variation in fruit quality attributes in different *mahua* genotypes. They also emphasized that early maturing genotypes had more juice content than late ones. It might be due to low temperature prevailing during early flowering period.

The kernel constitutes 68.53–85.71% of fruit by weight in different genotypes. It was highest in 'MH 4' that was closely followed by 'MH 2', 'MH 15', 'MH 7', 'MH 8', 'MH 10' and 'MH 12'. The oil content of kernel ranged from 40–46.50% and highest in 'MH 2' (46.50%) followed by 'MH 4', 'MH 10', 'MH 14', 'MH 9', 'MH 12', 'MH 18' and 'MH 19'.The chemical composition of kernel also showed variation in terms of protein and minerals (Table 3). The highest protein and mineral contents were recorded in 'MH 2', i e 24% and 4.90%, respectively it was closely followed by 'MH 4', 'MH 10', 'MH 11', 'MH 18' and 'MH 5'. *Mahua* can play an important role in vegetable oil production, as it is one of the highest yielding trees/unit area. Singh *et al.* 1999 observed similar results in different *mahua* genotypes. Genetic diversity in kernel characters among different genotypes of pecan nut and Persian walnut was also recorded under cold arid conditions (Thompson and Baker, 1993, Sharma and Sharma 2001 and Kaushal and Sharma 2002). Among genotypes studied, 'MH 2', 'MH 4', 'MH 5', 'MH 7', 'MH 10', 'MH 14', 'MH 16' and 'MH 18' were found to be promising on the basis of desired horticultural characters. Vegetatively propagated promising genotypes have been planted in the field for their further evaluation.

SUMMARY

In a survey carried out during 2003 and 2004 in the district Panchmahals and adjoining areas to identify the elite genotypes of *mahua* (*Bassia latifolia* Roxb.) among its population, revealed that there was a wide variation among the *mahua* (*Bassia latifolia* Roxb.) genotypes. Early flowering was observed in the first week of March in 'MH 1', 'MH 4', 'MH 5' while late (second week of April) in 'MH 6'. Flowers (45) and fruits (8)/fascicle were noted highest in 'MH 2'. Dry flower yield varied from 30 to 46 kg/plant, being highest in 'MH 2'. Fruit yield among the genotypes ranged from 35 kg to 82 kg/plant, with maximum in 'MH 2'.The highest total soluble solids (27.80%), total sugar (24.24%) and vitamin C content (64.00 mg/100g) was recorded in flowers of 'MH 4'. Maximum fruit weight (34.50), seed weight (14.50 g), kernel oil (46.50%), minerals (4.90%) and protein content (24%) were found in 'MH 2'. These genotypes would be exploited as potential parents to develop high yielding stable genotypes having positive horticultural traits.

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