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Genetic divergence in khirni (*Manilkara hexandra*) under semi- arid ecosystem of western India

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ABSTRACT

The present study was undertaken to evaluate the performance of 30 genotypes of khirni [*Manilkara hexandra* (Roxb.) Dubard], at Experimental Farm of Central Horticultural Experiment Station (ICAR-CIAH), Vejalpur, Panchmahals (Godhra), Gujarat under rainfed hot semi-arid ecosystem of western India during 2011-14. The results of study revealed that the different genotypes of khirni exhibited considerable variation for vegetative, floral, yield and physicochemical characters. The vegetative growth in terms of plant height, rootstock girth, scion girth, plant spread (East-West) and plant spread (North-South) varied between 2.50-5.54 m, 30.12-53.45 cm, 26.12-44.42 cm, 2.10-5.10 m and 2.30-5.20 m, respectively. Number of leaves/shoot varied between 10.12-16.12. The period of flowering was recorded in November-December in all the genotypes. Pollen viability and pollen germination ranged from 84.23-94.86% and 15.00-23.56% respectively, being highest in CHESK-10. Fruit set per cluster ranged from 2.00 to 3.70 being highest in CHESK-10. Peak period of ripening in majority of the genotypes was recorded in May. Maximum fruit yield (10.10 kg/plant), fruit weight (5.20 g), pulp (87.50%), TSS (24.73° Brix), total sugar (17.80%) and carotene (6.80 mg/100 g) was recorded in CHESK-10. Based on the horticultural traits studied, the genotypes, CHESK-10, CHESK12, CHESK-15 and CHESK-4 were found to be promising under rainfed hot semi-arid conditions of western India. The genotype CHESK-10 was released as variety named as Thar Rituraj.

Key words: Ecosystem, Genotypes, Pollen germination, Pollen viability

Khirni or rayan [*Manilkara hexandra* (Roxb.) Dubard] is an economically multipurpose tree of the family Sapotaceae. The tree is medium size, evergreen with spreading growth habit. It bears oval, sweet edible fruit with one or more seeds. It is commercially used as a rootstock for vegetative propagation of sapota in different parts of the country. The fruit is good source of iron, sugars, minerals, protein and carbohydrate etc. The plant can tolerate drought conditions if occurs for some time as well as heavy rainfall conditions.

Hot semi- arid zone is characterised by the low annual rainfall (750 mm) and the rainy spells are confined to three wet months (July to September) and the remaining parts of the year are dry months. The rains are also erratic and often come in a few storms of short duration which results in great runoff without charging the soil moisture profile resulting into water stress in soil during major parts of the year. Arid and semi-arid regions have peculiar eco-climatological features in which several major agronomical crops fail to sustain. It is very hardy and thrives well on rocky and gravelly soils. It is a 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. Elite genotypes were collected from the existing population of khirni based on the horticultural traits and evaluated under field condition to develop khirni variety having earliness, short stature, precocious bearer, high yielder, high pulp content and suitable for high density planting under semi-arid conditions of western India. Variations were observed in flowering, fruiting, yield and fruit quality attributes in jamun, chironji, tamarind and khirni under different climatic conditions (Patel *et al*. 2005, Singh *et al.* 2006*,* Singh *et al.* 2007, Singh and Singh 2012, Malik *et al*. 2012 and Malik *et al*. 2013). Present investigation was carried out to find out variability in plant growth, flowering, fruiting and fruit quality attributes of different genotypes of khirni, so that the suitable variety could be developed under crop improvement programme.

MATERIALS AND METHODS

The annual rainfall was mainly confined to three months (July- September) and actual mean precipitation was about 750 mm. The mean summer temperature was 32.9° C while the mean winter temperature is 21.3°C indicating that the area falls under hyperthermic soil regime. The mean annual

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maximum and minimum temperature varied from 42-44° C and 6 - 9°C in January, respectively. The soil depth of experimental field ranged from 0.65 to 1.0 m derived from mixed alluvial basalt, quartzite, granite and layers of limestone, and falls under semi-arid hot climate.

A total of 30 genotypes were established through *in-situ* softwood grafting during 2005. The experiment was laid out in randomized block design with three replications, observations on plant growth, flowering, fruiting and fruit quality attributes were observed during three consecutive years (2011-12, 2012-13 and 2013-14) and mean data were presented in the tables. Twenty shoots spread over four directions on each tree were tagged and detail observations on floral traits were recorded. The pollen viability in different genotypes was tested with two per cent acetocarmene solution. The pollen from freshly dehisced anthers was put on the slides. About 2 drops of freshly prepared 2% acetocarmine solution was added to the slides and was covered gently with a cover slip. The mounted pollens were examined under the microscope after about 15 min, when they had attained proper staining. Pollen which stained deeply, looked normal and symmetrical were considered to be viable and the remaining ones as non-viable (Dhaliwal and Singla 2003). Observations on pollen germinability were recorded by using hanging drop method in 15% sucrose solution after 24 hrs. Fruits were randomly selected from all the directions of the plant for fruit quality attributes. Total soluble solids, protein, vitamin C, sugars and carotene were analyzed by the method by AOAC (1980). The mean data were statistically analyzed as per method given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The data on vegetative growth of different genotypes depicted in Table 1 showed significant differences in respect of their vegetative characters. The plant height ranged between 2.50-5.54 m being highest in CHESK-1, it was recorded least in CHESK-26. The differences in root stock girth was significant, it was found to be highest in CHESK-1 (53.45cm) followed by CHESk-11(52.12 cm) CHESK-19 (52.00cm), while it was noted minimum in CHESK-26 (30.12cm). The scion girth was also noted maximum in GHESK-1 and minimum in CHESK-26. The plant spread (E-W-5.20 m and N-S-5.10m) was recorded maximum in CHESK-1, followed by CHESK-11**.** Number of leaves per shoot (Annual extension growth) was found to be maximum (16.12) in CHESK-28, closely followed by CHESK-30 and CHESK-27, it was noted least in CHESK-6 (10.12). Internodal length ranged between1.70-2.21 cm being highest in CHESK-29.The difference in vegetative growth of different genotypes may be due to their inherent characters under varied agro-climatic conditions. Similar results with respect to vegetative characters were reported by Singh and Singh 2012 and Singh *et al.* (2014) in jamun and bael under hot semi-arid conditions of western India.

The data on the flowering pattern of different genotypes depicted in Table 1 showed considerable differences. The period of flowering was recorded in November and December in different genotypes**.** It was noted earliest in 2nd week of November in CHESK-6 while, it was observed at the last in the 4th week of December in CHESK-8, CHESK-16, CHESK-20 and CHESK-26. Days taken from flowering to fruit set ranged from 8.40-13.18 being highest in CHESK-26. Days taken for bud development varied between 21.12-26.20 being highest in CHESK-10. There was marked variation in fruit set per cluster and CHESK-10 recorded maximum fruit set (3.70), closely followed by CHESK-9, CHESK-4 and CHESK-13. Least fruit set was noted in CHESK-22. The variability in respect of flowering period also reported by Singh (2002), Dobral and Misra (2007) and Singh *et al*. (2008) in mango, litchi and tamarind. Meghwal and Azam (2004) and Singh and Singh (2005) also recorded remarkable variability in aonla and mahua genotypes under Rajasthan and Gujarat conditions, respectively. Wide variability in respect of flowering was recorded in mango, jamun and chironji under different climatic conditions (Singh 2002, Hoda *et al.* 2003, Singh and Singh 2005, Singh *et al*. 2006, Singh *et al*. 2010b). Variability in fruit set was also recorded in jamun genotypes (Singh *et al*. 2007).

Maximum pollen viability (94.86%) was observed in CHESK-10, which was closely followed by CHESK-2 and CHESK-5, however minimum pollen viability was observed in CHESK-4 (84.23%). Kumar *et al.* (2004) reported that pollen viability ranged from 74.90-94.22% in different peach cultivars under Uttaranchal conditions. Singh *et al*. (2004) obtained 75.60-88.00% pollen viability in different pear cultivars. Pollen germination was poor irrespective of the genotypes (Table 2). The maximum pollen grain germination was recorded in CHESK-10 (23.56%) closely followed by CHESK-27, CHESK-2 and CHESK-6, while it was found to be least in CHESK-15 (15.00%). Differences in pollen germination may be due to varying percentage of pollen viability in different genotypes. Kumar *et al*. (2004) reported that pollen germination ranged from 62.12-78.23% in different peach cultivars under Uttaranchal conditions. Pollen grain viability ranged from 91.05-97.91% among different genotypes of pomegranate (Sharma and Bist 2003). Dhaliwal and Singla (2003), Hoda *et al*. (2003), Singh *et al*. (2004), Singh and Singh (2005) and Singh *et al.* (2010 b) recorded wide variation in reproductive attributes of guava, mango, tamarind, *Mahua* (*Bassia latifolia* Roxb.) and chironji, respectively, under various climatic conditions.

Variability recorded in ripening time, physical and biochemical characters of khirni fruits are presented in Table 2. Earliest ripening (3rd week of April) was recorded in CHESK- 29 and CHESK- 30, while it was late (2nd week of May) in CHESK-1, CHESK- 2, CHESK- 3, CHESK-12, CHESK- 13, CHESK-18, CHESK- 19, CHESK- 23 and CHESK- 27.

The highest fruit yield (10.10 kg) per plant was found in CHESK-10 closely followed by CHESK-12, CHESK-15 and CHESK-27. The least fruit yield was recorded in CHESK-26. The study was undertaken to investigate the nature and extent of variability present in bael and high degree of variability

Table 1 Plant growth and flowering pattern of different khirni genotypes (Mean data 2011-12, 2012-13 and 2013-14)

Genotype	Plant height (m)	Root stock girth (cm)	Scion girth (cm)	Plant spread (N-S) m	Plant spread (E-W)m	No. of leaves/ shoot (Annual extension growth)	Internodal length (cm)	Flowering time	Days taken from flowering to fruit set	Days taken for bud development	Fruit set /cluster	Pollen viability (%)	Pollen germination (%)
CHESK-1	5.54	53.45	44.42	5.10	5.20	15.12	1.85	3rd week Nov.	9.12	22.50	2.20	92.21	20.23
CHESK-2	4.30	44.12	38.21	4.10	4.12	13.12	1.80	4th week Nov.	10.12	21.20	2.10	93.65	21.12
CHESK-3	4.35	44.21	38.25	4.00	4.10	12.12	1.92	3rd week Nov.	10.40	21.50	2.60	85.21	19.23
CHES K-4	4.41	44.30	38.56	4.10	4.20	13,15	2.10	3rd week Nov.	8.50	24.40	3.50	84.23	17.15
CHESK-5	3.92	38.24	34.21	3.61	3.70	11.12	2.12	2nd week Dec.	9.80	22.12	2.10	93.20	18.16
CHESK-6	2.70	32.10	27.20	2.36	2.45	10.12	2.00	2nd week Nov.	8.40	22.12	2.80	90.12	21.23
CHESK-7	2.92	33.20	28.10	2.52	2.70	14.12	1.82	3rd week Dec.	11.20	24.50	2.40	86.32	20.12
CHESK-8	4.54	42.18	36.11	4.31	4.38	15.10	1.80	4th week Dec.	11.50	22.12	3.50	89.23	16.12
CHES K-9	4.47	42.23	36.20	4.11	4.21	14.45	1.82	3rd week Dec.	12.50	24.40	3.60	86.35	15.12
CHESK-10	4.36	44.46	38.85	4.00	4.21	14.13	2.06	1st week Dec.	10.80	26.20	3.70	94.86	23.56
CHESK-11	5.10	52.12	48.14	4.70	4.85	13.10	2.12	2nd week Dec.	10.18	25.50	3.10	91.23	18.15
CHESK-12	4.60	44.80	40.20	4.22	4.40	11.13	2.20	3rd week Dec.	9.20	24.00	3.40	93.23	17.12
CHESK-13	3.48	38.10	34.12	3.11	3.21	10.14	2.13	3rd week Dec.	11.80	20.80	3.50	91.32	16.12
CHES K-14	4.68	43.13	38.20	4.20	4.41	10.47	2.16	3rd week Dec.	12.70	22.00	3.10	86.23	15.12
CHESK-15	4.70	43.15	38.30	4.42	4.51	11.50	2.00	3rd week Dec.	12.60	24.12	3.20	86.30	15.00
CHESK-16	3.40	38.00	34.00	3.10	3.21	13.12	1.98	4th week Dec.	13.12	22.50	2.80	91.63	17.20
CHESK-17	2.80	32.14	28.10	2.50	2.60	13.19	1.85	3rd week Dec.	10.50	21.12	2.70	92.12	21.20
CHESK-18	4.48	37.52	32.10	4.10	4.25	12.10	1.82	2nd week Dec.	12.20	21.12	2.50	90.10	21.32
CHESK-19	5.10	52.00	48.20	4.70	4.82	12.44	1.75	2nd week Dec	10.50	23.00	2.30	92.20	21.52
CHES K-20	3.49	38.16	34.12	3.12	3.25	11.13	1.70	4th week Dec.	8.80	22.10	2.60	89.20	20.00
CHESK-21	3.60	38.89	32.12	3.20	3.40	15.12	1.99	2nd week Dec.	9.40	22.20	3.30	88.65	21.00
CHESK-22	2.64	31.20	27.21	2.10	2.40	14.36	2.20	1st week Dec	10.20	22.80	2.00	90.20	20.20
CHESK-23	4.65	44.32	40.13	4.20	4.41	13.89	2.15	3rd week Dec.	11.30	23.40	2.10	91.23	19.12
CHESK-24	4.90	44.65	39.20	4.60	4.70	12.56	2.13	3rd week Dec.	12.40	21.20	2.30	89.23	19.22
CHES K-25	3.90	33.62	29.23	3.50	3.70	12.12	2.10	2nd week Dec.	12.80	23.40	2.40	84.60	15.12
CHESK-26	2.50	30.12	26.12	2.10	2.30	14.50	2.11	4th week Dec.	13.18	22.10	2.70	89.12	19.32
CHESK-27	2.82	31.24	27.20	2.6	2.70	15.16	2.12	1st week Dec.	11.00	22.40	3.40	87.20	22.20
CHESK-28	4.78	38.60	34.12	4.71	4.60	16.12	2.12	2nd week Dec.	11.20	23.21	2.20	86.10	20.25
CHESK-29	4.99	44.70	40.12	4.71	4.81	13.13	2.21	2nd week Dec	12.80	22.21	2.14	86.32	19.12
CHESK-30	3.21	32.65	26.23	2.90	3.00	15.65	1.86	1st week Dec.	10.80	22.00	3.10	89.20	18.50
CD(P=0.05)	0.75	1.20	1.22	0.52	0.42	0.54	0.15		0.21	0.24	0.11	1.20	0.58

Table 2 Ripening time, yield and fruit quality attributes of promising Khirni genotypes (Mean data 2011-12, 2012-13 and 2013-14)

Genotype	Ripening time	Fruit yield /plant(kg)	Fruit weight (g)	Seed weight (g)	Pulp weight(g)	Pulp (%)	TSS ^{o} Brix	Acidity (%)	Vitamin C (mg/100g)	Total sugar (%) su	Reducing sugar (%)	Carotene (mg/100 g)
CHESK-1	4th week May	6.10	4.20	0.71	3.49	83.10	22.00	0.35	27.12	15.00	7.12	4.20
CHESK-2	4th week May	5.21	4.30	0.65	3.65	84.88	23.00	0.36	26.30	15.30	7.00	5.45
CHESK-3	4th week May	4.50	3.20	0.61	2.59	80.94	22.10	0.37	25.10	15.10	6.80	5.55
CHES K-4	1st week May	7.00	3.50	0.53	2.97	84.86	23.15	0.32	30.20	15.40	7.30	5.40
CHESK-5	3rd week May	6.50	3.10	0.63	2.47	79.68	22.10	0.31	29.20	13.80	6.30	5.15
CHESK-6	3rd week May	5.10	3.00	0.62	2.38	79.33	22.80	0.29	24.50	13.90	6.70	4.85
CHESK-7	3rd week May	4.20	4.89	0.65	4.24	86.71	21.00	0.38	28.00	13.12	6.10	5.25
CHESK-8	3rd week May	6.50	5.00	0.73	4.27	85.40	22.20	0.36	26.20	14.00	6.90	5.42
CHES K-9	3rd week May	5.10	4.20	0.70	3.50	83.33	23.00	0.38	25.10	15.10	7.10	5.13
CHESK-10	3rd week May	10.10	5.20	0.65	4.55	87.50	24.73	0.32	28.33	17.80	9.78	6.80
CHESK-11	2nd week May	7.20	4.07	0.63	3.44	84.52	23.90	0.34	32.23	16.62	8.12	6.35
CHESK-12	4th week May	8.10	5.10	0.65	4.45	87.25	24.00	0.38	27.40	16.80	8.20	6.50
CHESK-13	4th week May	4.50	4.20	0.61	3.59	85.48	23.90	0.37	25.00	16.60	8.10	6.06
CHES K-14	3rd week May	5.60	4.60	0.62	3.98	86.52	22.60	0.37	24.20	15.10	7.20	5.13
CHESK-15	1st week May	8.20	3.20	0.53	2.67	83.44	23.10	0.38	25.20	16.41	8.00	4.55
CHESK-16	2nd week May	5.21	3.55	0.54	3.01	84.79	22.10	0.39	22.58	15.00	6.80	5.50
CHESK-17	2nd week May	4.30	4.10	0.56	3.54	86.34	23.00	0.35	26.40	16.00	8.00	4.83
CHESK-18	4th week May	6.20	4.20	0.62	3.58	85.24	21.02	0.39	24.00	13.10	6.10	5.65
CHESK-19	4th week May	5.10	3.30	0.54	2.76	83.64	21.20	0.32	23.20	13.20	6.20	5.52
CHES K-20	3rd week May	6.20	3.40	0.56	2.84	83.53	20.50	0.33	22.20	13.00	6.06	5.33
CHESK-21	2nd week May	4.20	3.00	0.62	2.38	79.33	22.32	0.30	23.13	14.60	7.10	6.42
CHESK-22	3rd week May	5.41	3.20	0.52	2.68	83.75	23.20	0.32	26.00	16.12	4.10	6.55
CHESK-23	4th week May	5.00	4.00	0.61	3.39	84.75	21.00	0.26	25.48	13.00	6.10	6.12
CHESK-24	1st week May	4.20	4.11	0.58	3.53	85.89	22.12	0.37	24.89	14.12	6.80	6.10
CHES K-25	2nd week May	6.20	4.10	0.54	3.56	86.83	22.14	0.36	25.29	14.20	6.90	5.53
CHESK-26	1st week May	3.20	4.40	0.58	3.82	86.82	23.60	0.38	24.22	15.30	7.12	5.89
CHESK-27	4th week May	8.20	3.60	0.65	2.95	81.94	22.15	0.33	21.12	15.20	7.07	6.10
CHESK-28	2nd week May	7.10	3.80	0.61	3.19	83.95	23.25	0.36	24.22	15.10	7.00	6.40
CHESK-29	3rd week April	6.30	3.40	0.53	2.87	84.41	22.30	0.39	23.00	14.50	6.85	6.00
CHESK-30	3rd week April	5.10	3.40	0.59	2.81	82.65	21.20	0.37	21.20	13.12	6.20	6.10
CD(P=0.05)		0.15	0.12	0.02	0.10	0.21	0.11	0.03	0.23	0.15	0.12	0.13

was observed with regard to fruit yield, fruit size and fruit weight (Singh *et al.* 2014). The fruit weight ranged from 3.00-5.20g and it was found to be highest in CHESK-10, followed by CHESK-12 and CHESK-8. Maximum seed weight was found in CHESK-8 followed by CHESK-1 and CHESK-9. The fruits of CHESK-10 recorded maximum pulp per cent (87.50%) closely followed by CHESK-12 and CHESK-25, while it was found least in CHESK-CHESK-6 and CHESK-21. Khirni fruits are also rich source of total soluble solids, sugars, vitamin C and carotene and these values varied significantly in different genotypes. Total soluble solids and total sugar content of fruits ranged from 20.50 to 24.73° Brix and 13.00 to17.80%, respectively, in different genotypes. The highest Total soluble solids (TSS) was recorded in CHESK-10 (24.73° Brix), followed by CHESK-12 (24.00° Brix) and CHESK-11(23.90° Brix). Maximum total sugar content was found in CHESK-10 (17.80%), closely followed by CHESK-12 (16.80%) and CHESK-11(16.62%). Vitamin C content was found to be highest in CHESK-11 (32.33 mg/100g) closely followed by CHESK-4 (30.20 mg/100g) and CHESK-5(29.20 mg/100g), whereas CHESK-27 recorded the lowest (21.12 mg/100g). Ram and Singh (2003), Machewade *et al.* (2003) and Singh *et al.* (2010b) have also recorded the variation in fruit quality attributes in different bael and chironji genotypes. Vitamin C content varied from 0.26-0.39 mg/100g being highest in CHESK-29. Highest carotene content was recorded in CHESK-10 (6.80 mg/100g), closely followed by CHESK-12 and CHESK-22. The remarkable variability was observed in relation to fruit quality attributes of khirni (Malik et al, 2012). Based on the horticultural traits studied, the genotypes, CHESK-10, CHESK12, CHESK-15 and CHESK-4 were found to be promising under rainfed hot semi-arid conditions of western India. The genotype CHESK-10 was released as variety named as Thar Rituraj.

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