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Studies on Morphology and Physical Attributes of Mango Varieties

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A B S T R A C T

The varietal evaluation study was conducted on 43 mango cultivars at Horticulture Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The fruit shape, weight, size, pulp stone ratio, fibre content, lenticels density and other surface morphological traits of different varieties were evaluated in Randomized Block Design for two consecutive years i.e. 2012-13 and 2013-14. Significant variations were observed among the varieties for the various attributes studied. The fruit shape of different varieties varied from circular to broad elliptic, with few varieties exhibiting medium elliptic shape. The entire course of study as well as the pooled results indicated that the variety Haathijhool was most promising in terms of fruit weight (1906.30 g), size (199.06 mm length and 128.95 mm breadth) and pulp stone ratio (10.50). However, the variety was also adjudged as most fibrous with a fibre content of 5.35 per cent.

Introduction

Mango, popularly known as the "king of fruits", is an important tropical fruit of the world. It is the major fruit crop of India, which covers an area of ha with an annual production of t (NHB,). Owing to its wide adaptability, mango is commercially produced in majority of the states. These include Andhra Pradesh, Uttar Pradesh, Bihar, Karnataka, Tamil Nadu, West Bengal, Orissa and Maharashtra. Uttar Pradesh. The region wise popular varieties grown in different parts of the country comprise of 'Alphonso' and 'Kesar' in western India, 'Banganpalli', 'Totapuri' and 'Neelum' in southern states, 'Bombai', 'Gulabkhas', 'Malda', 'Zardalu' and 'Fazli' in eastern states and 'Dashehari', 'Langra' and 'Chausa' in northern states.

In Uttarakhand, mango occupies 19.68 per cent of the total area under horticultural crops with a total production of 17.08 per cent (Tuteja, 2013). A wide variety of mango cultivars are grown in the different regions of the state. In terrain region of Uttarakhand, a good collection of mango germplasm is maintained at HRC, Pantnagar. However, the yield and other related attributes of these varieties widely vary depending on their genetic constitution and further its interaction with the environmental conditions. Hence, a

detailed assessment of the performance of these varieties including their fruit morphology and other physical attributes is necessary for upcoming crop improvement and fruit breeding programmes. The information generated may also aid the consumers and processing industries, since, the physical characteristics of mango fruits like fruit weight, size, per cent of fibre content etc. play a crucial role in selection for table purpose and processing. So, keeping these points in mind, the present study was carried to evaluate the different mango genotypes for their fruit surface morphology and other related physical attributes.

Materials and Methods

The present study was conducted to evaluate the morphological and physical attributes of different mango varieties available at Horticulture Research Centre (HRC), Patharchatta, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. Pantnagar is situated at the foot hills of the Himalaya at 29° North latitude and 79.3° East longitude. The soil of the experimental site has been classified as silty clay loam under the mollisol (Deshpande *et al.,* 1971). The experimental study was conducted on fourty-three mango varieties, during 2012 and 2013.

The evaluation parameters included surface morphological characteristics like fruit shape, surface, presence of neck and sinus, lenticels density and few physical attributes such as fruit weight, size, pulp stone ratio, waste index and fibre per cent.

The fruit shape, surface and presence of neck and sinus were recorded visually while, the lenticels density was determined as number of lenticels per cm^2 of the fruit surface which was calculated by randomly selecting 1 cm^2 area of fruit surface and counting the number of lenticels with hand lens magnifier. The fruit weight and size was measured through electronic weighing balance and digital Vernier callipers, respectively. The pulp to stone ratio is the ratio of pulp weight and stone weight while, waste index is the ratio of pulp weight and combined weight of stone and peel.

Results and Discussion

The surface morphological traits of different mango varieties are mentioned in Table 1, which revealed a significant variation in fruit morphology among varieties. In terms of fruit shape, varieties like Khas-ul-Khas, Langra Gorakhpur, Langra Rampur, Mithua Malda, Mulgoa Deshi, Pulgoa Darbhanga, Vanraj and Zafrani Gola exhibited circular shape while broad elliptic shape was found in Bara Malda, Bathui, Bijoragarh, Bombay Green, Bride of Russia, Dudha Peda, Gulabkhas, Gurwani, Haathijhool, Kaitki Bihar, Kesar (Basti), K.O.-07, Langra, Rahman Pasand, Rataul, Rumani, Sensation, Suvarnrekha, Tamancha and Totapari Red Small. The remaining varieties observed medium elliptic shape.

The fruit surface also differed among the varieties in both the years of study. Most of the varieties were adjudged with a smooth surface including Amrapalli, Bara Malda, Banarasi Betali, Baramasi, Bathui, Bijoragarh, Bombay Green, Chausa, Dashehari, Dashehari-51, Duddha Peda, Gulabkhas, Gulabkhas Green, Gurwani, Husn-a-ra, Kaitki Bihar, Kesar (Basti), Khas-ul-Khas, Langra, Langra Gorakhpur, Langra Rampur, Mallika, Mulgoa Deshi, Neelum×Chausa, Pulgoa Darbhanga, Rahman Pasand, Rataul, Rumani, Safeda Lucknow Sensation, Suvarnrekha, Tamancha, Totapari Red Small, Vanraj and Zardalu, while, rough fruit surface was observed among remaining varieties. Mango varieties also differed for presence of neck and sinus in mango fruits.

Table.1 Studies on fruit morphological characteristics of mango varieties in 2012 and 2013

Variety	Fruit Shape	Fruit Surface	Presence of Neck	Presence of Sinus
1	2	3	4	5
Amin	Medium Elliptic	Rough	Absent	Present
Amrapali	Medium Elliptic	Smooth	Present	Present
Bara Malda	Broad Elliptic	Smooth	Absent	Present
Banarasi Betali	Medium Elliptic	Smooth	Absent	Absent
Baramasi	Medium Elliptic	Smooth	Present	Present
Bathui	Broad Elliptic	Smooth	Present	Absent
Bijoragarh	Broad Elliptic	Smooth	Present	Absent
Bombay Green	Broad Elliptic	Smooth	Absent	Present
Bride of Russia	Broad Elliptic	Rough	Absent	Absent
Chausa	Medium Elliptic	Smooth	Absent	Present
Dashehari	Medium Elliptic	Smooth	Absent	Present
Dashehari-51	Medium Elliptic	Smooth	Absent	Present
Duddha Peda	Broad Elliptic	Smooth	Absent	Absent
Gulabkhas	Broad Elliptic	Smooth	Absent	Absent
Gulabkhas Green	Medium Elliptic	Smooth	Present	Present
Gurwani	Broad Elliptic	Smooth	Absent	Present
Haathijhool	Broad Elliptic	Rough	Present	Absent
Husn-a-ra	Medium Elliptic	Smooth	Absent	Present
Kaitki Bihar	Broad Elliptic	Smooth	Absent	Absent
Kesar (Basti)	Broad Elliptic	Smooth	Present	Present
Khas-ul-Khas	Circular	Smooth	Absent	Absent
K.O.-07	Broad Elliptic	Rough	Absent	Present
Langra	Broad Elliptic	Smooth	Present	Present
Langra Gorakhpur	Circular	Smooth	Present	Present
Langra Rampur	Circular	Smooth	Absent	Absent
Mallika	Medium Elliptic	Rough	Present	Present
Mithua Malda	Circular	Rough	Absent	Absent
Mulgoa Deshi	Circular	Smooth	Present	Absent
Neelum	Medium Elliptic	Rough	Absent	Present
Neelum×Chausa	Medium Elliptic	Smooth	Absent	Present
Pulgoa Darbhanga	Circular	Smooth	Absent	Present
Rahman Pasand	Broad Elliptic	Smooth	Absent	Absent
Rataul	Broad Elliptic	Smooth	Absent	Absent
Rumani	Broad Elliptic	Smooth	Absent	Present
Safeda Lucknow	Medium Elliptic	Smooth	Absent	Absent
Sensation	Broad Elliptic	Smooth	Absent	Present
Suvarnrekha	Broad Elliptic	Smooth	Present	Present
Tamancha	Broad Elliptic	Smooth	Absent	Absent
Thanking Amadi	Medium Elliptic	Rough	Present	Present
Totapari Red Small	Broad Elliptic	Smooth	Present	Present
Vanraj	Circular	Smooth	Absent	Absent
Zafrani Gola	Circular	Rough	Absent	Absent
Zardalu	Medium Elliptic	Smooth	Absent	Absent

Table.2 Studies on fruit weight and size of different mango varieties in 2012 and 2013

Variety	Fruit weight (g)			Fruit length (mm)			Fruit breadth (mm)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Amin	204.81	205.83	205.32	107.26	118.79	113.03	61.26	60.09	60.68
Amrapali	189.52	204.38	196.95	99.00	106.82	102.91	58.34	62.12	60.23
Bara Malda	137.74	156.58	147.16	78.21	82.99	80.60	65.42	72.02	68.72
Banarasi Betali	336.34	370.67	353.50	121.67	129.98	125.83	65.67	74.92	70.30
Baramasi	225.06	221.49	223.28	110.38	107.53	108.96	61.55	59.18	60.37
Bathui	223.86	202.92	213.39	107.80	98.16	102.98	54.13	54.85	54.49
Bijoragarh	298.41	316.67	307.54	97.83	104.87	101.35	83.72	87.12	85.42
Bombay Green	235.67	255.69	245.68	92.23	97.94	95.09	67.76	73.05	70.40
Bride of Russia	266.92	281.92	274.42	93.55	94.47	94.01	75.07	79.21	77.14
Chausa	330.01	343.33	336.67	104.02	115.53	109.78	71.47	76.62	74.05
Dashehari	161.81	174.00	167.91	91.93	100.42	96.18	54.52	58.41	56.47
Dashehari-51	171.53	185.41	178.47	98.99	101.27	100.13	54.76	58.21	56.48
Duddha Peda	140.54	162.92	151.73	84.78	101.25	93.02	54.20	60.30	57.25
Gulabkhas	219.76	242.72	231.24	102.34	103.13	102.73	67.67	66.93	67.30
Gulabkhas Green	162.39	139.28	150.84	92.09	88.79	90.44	60.64	57.95	59.30
Gurwani	226.51	254.17	240.34	91.21	92.15	91.68	71.33	76.28	73.80
Haathijhool	1906.30	1754.10	1830.20	203.19	194.93	199.06	133.80	124.07	128.95
Husn-a-ra	146.92	132.08	139.50	100.11	89.29	94.70	51.21	51.02	51.11
Kaitki Bihar	230.41	200.26	215.33	83.98	75.19	79.59	73.72	65.70	69.71
Kesar (Basti)	237.78	267.08	252.43	124.17	135.37	129.77	58.73	63.36	61.05
Khas-ul-Khas	222.78	242.47	232.63	93.48	100.68	97.08	66.32	70.76	68.54
K.O.-07	235.71	252.93	244.32	87.36	96.39	91.88	67.46	70.77	69.12
Langra	295.66	311.43	303.55	103.36	106.26	104.81	68.47	74.22	71.35
Langra Gorakhpur	334.58	293.75	314.17	137.11	130.35	133.73	67.56	67.77	67.66
Langra Rampur	274.36	260.83	267.60	109.88	98.95	104.42	77.91	73.35	75.63
Mallika	431.58	419.91	425.75	154.36	147.49	150.93	82.78	76.41	79.60
Mithua Malda	209.95	220.83	215.39	95.62	102.72	99.17	68.20	67.77	67.99
Mulgoa Deshi	331.99	357.52	344.76	87.41	100.07	93.74	79.83	85.10	82.47
Neelum	123.89	132.48	128.18	78.54	76.97	77.76	56.67	61.48	59.07
Neelum×Chausa	278.89	314.17	296.53	117.81	125.96	121.89	66.40	71.85	69.13
Pulgoa Darbhanga	269.57	250.18	259.88	101.59	94.62	98.11	71.58	65.50	68.54
Rahman Pasand	279.44	291.39	285.42	97.02	109.20	103.14	80.18	71.34	75.76
Rataul	172.36	145.28	158.82	85.70	77.60	81.65	67.12	54.86	60.99
Rumani	160.69	179.67	170.18	68.64	72.83	70.74	70.53	71.73	71.13
Safeda Lucknow	125.11	135.83	130.47	78.33	80.81	79.57	50.06	58.34	54.20
Sensation	247.75	265.42	256.58	103.43	114.72	109.08	69.52	72.51	71.02
Suvarnrekha	402.67	392.22	397.45	111.15	107.08	109.12	80.34	79.23	79.78
Tamancha	113.64	104.59	109.12	67.16	62.96	65.06	52.50	55.12	53.81
Thanking Amadi	250.53	254.50	252.51	103.44	105.95	104.69	71.38	69.20	70.29
Totapari Red Small	118.36	119.58	118.97	88.10	89.16	88.63	53.50	54.33	53.92
Vanraj	302.99	310.20	306.60	96.80	98.31	97.56	78.09	80.50	79.29
Zafrani Gola	221.69	220.42	221.05	77.82	78.56	78.19	75.27	71.85	73.56
Zardalu	203.45	226.73	215.09	106.98	104.73	105.86	62.37	65.97	64.17
S.Em.±	4.22	9.69	5.04	1.92	1.88	1.41	1.04	1.21	0.81
C.D. at 5%	11.86	27.25	14.18	5.41	5.29	3.98	2.92	3.39	2.29

Table.3 Studies on fruit physical parameters of different mango varieties in 2012 and 2013

Variety	Pulp : stone ratio			Waste index			Fibre content (%)			Lenticel density (%)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Amin	2.41	2.78	2.60	1.68	1.89	1.79	2.28	2.35	2.31	21.50	23.34	22.42
Amrapali	4.31	5.00	4.65	2.44	2.52	2.48	2.35	2.81	2.58	14.12	13.55	13.84
Bara Malda	3.47	3.57	3.52	2.63	2.72	2.68	2.89	3.14	3.01	11.52	11.48	11.50
Banarasi Betali	6.31	6.22	6.26	3.45	3.27	3.36	2.58	2.54	2.56	8.13	8.32	8.22
Baramasi	3.46	3.52	3.49	2.09	2.16	2.12	2.14	1.93	2.04	14.45	15.36	14.91
Bathui	3.07	2.41	2.74	1.75	1.65	1.70	2.98	1.89	2.44	11.07	10.68	10.87
Bijoragarh	5.57	4.92	5.24	2.99	2.64	2.82	2.42	3.33	2.87	13.06	12.85	12.96
Bombay Green	3.13	2.75	2.94	1.94	1.67	1.80	0.94	0.94	0.94	7.15	7.74	7.44
Bride of Russia	2.53	3.34	2.94	1.46	1.69	1.57	2.63	2.85	2.74	13.70	13.43	13.57
Chausa	3.96	4.77	4.37	2.46	2.70	2.58	1.57	1.57	1.57	31.86	28.54	30.20
Dashehari	2.99	2.82	2.90	1.57	1.43	1.50	1.61	1.98	1.79	19.29	19.22	19.26
Dashehari-51	4.96	4.94	4.95	2.06	2.06	2.06	0.87	0.77	0.82	21.33	19.46	20.40
Duddha Peda	4.01	3.79	3.90	2.45	1.93	2.19	0.79	0.82	0.81	8.09	8.26	8.18
Gulabkhas	2.89	3.26	3.08	1.80	1.78	1.79	2.20	2.82	2.51	21.90	22.06	21.98
Gulabkhas Green	2.51	2.56	2.53	1.45	1.59	1.52	0.89	0.68	0.79	11.43	11.43	11.43
Gurwani	2.59	2.32	2.46	1.63	1.45	1.54	2.46	2.80	2.63	15.83	15.14	15.48
Haathijhool	10.60	10.30	10.50	5.30	5.24	5.27	5.27	5.43	5.35	21.49	23.96	22.72
Husn-a-ra	1.98	1.90	1.94	1.36	1.46	1.41	0.94	0.80	0.87	34.66	37.68	36.17
Kaitki Bihar	4.33	4.37	4.35	2.50	2.84	2.67	0.76	0.47	0.62	18.34	18.28	18.31
Kesar (Basti)	1.79	2.12	1.95	0.69	0.79	0.74	1.94	2.39	2.17	10.13	11.06	10.60
Khas-ul-Khas	2.86	2.49	2.67	1.28	1.08	1.18	1.22	1.41	1.31	6.52	7.51	7.02
K.O.-07	1.93	1.89	1.91	1.04	0.98	1.01	2.17	2.82	2.50	10.18	10.48	10.33
Langra	4.66	4.24	4.45	2.87	2.53	2.70	1.64	1.72	1.68	21.51	22.38	21.95
Langra Gorakhpur	6.99	7.20	7.09	3.51	3.89	3.70	2.14	2.65	2.40	17.34	16.76	17.05
Langra Rampur	6.01	5.92	5.97	2.67	2.66	2.67	2.18	1.78	1.98	18.53	19.88	19.21
Mallika	7.37	8.90	8.13	3.93	4.64	4.29	1.25	1.72	1.48	29.08	24.76	26.92
Mithua Malda	3.40	3.81	3.61	1.76	1.84	1.80	1.33	1.15	1.24	9.49	8.95	9.22
Mulgoa Deshi	4.29	4.53	4.41	2.16	2.14	2.15	2.18	2.68	2.43	24.47	24.64	24.56
Neelum	3.78	3.69	3.73	2.56	2.28	2.42	1.21	1.33	1.27	13.94	14.54	14.24
Neelum×Chausa	3.72	4.08	3.90	2.17	2.26	2.22	1.67	2.15	1.91	15.12	16.57	15.85
Pulgoa Darbhanga	3.48	3.35	3.42	2.20	2.20	2.20	2.79	2.45	2.62	32.50	33.81	33.16
Rahman Pasand	2.58	2.57	2.58	1.65	1.63	1.64	3.63	3.72	3.68	24.56	24.10	24.33
Rataul	2.50	2.11	2.31	1.53	1.35	1.44	2.01	1.44	1.73	18.99	18.64	18.82
Rumani	3.42	4.96	4.19	2.64	3.46	3.05	0.77	0.77	0.77	49.57	51.58	50.57
Safeda Lucknow	2.94	3.23	3.08	2.23	2.34	2.28	1.32	1.05	1.19	13.38	13.34	13.36
Sensation	3.49	3.54	3.51	1.92	1.92	1.92	1.85	1.59	1.72	8.77	8.54	8.66
Suvarnrekha	7.13	7.18	7.15	3.68	3.72	3.70	1.53	0.88	1.21	12.03	10.83	11.43
Tamancha	2.88	2.87	2.87	1.64	1.83	1.74	0.90	0.97	0.93	8.06	8.24	8.15
Thanking Amadi	4.10	4.50	4.30	2.19	2.15	2.17	1.84	1.83	1.83	15.17	15.06	15.12
Totapari Red Small	3.17	3.13	3.15	2.21	2.06	2.14	0.72	0.73	0.72	23.21	25.51	24.36
Vanraj	7.63	7.91	7.77	4.00	3.91	3.96	1.65	1.86	1.76	21.90	18.60	20.25
Zafrani Gola	6.18	6.36	6.27	2.55	2.47	2.51	1.59	1.55	1.57	31.71	35.39	33.55
Zardalu	2.13	2.68	2.40	1.59	1.85	1.72	1.05	1.32	1.19	10.46	10.55	10.51
S.Em.±	0.10	0.11	0.12	0.06	0.11	0.06	0.10	0.07	0.06	2.15	1.94	1.58
C.D. at 5%	0.29	0.31	0.33	0.17	0.31	0.17	0.29	0.19	0.17	6.06	5.47	4.44

The presence of neck was noted in mango varieties like Amrapali, Baramasi, Bathui, Bijoragarh, Gulabkhas Green, Haathijhool, Kesar (Basti), Langra, Langra Gorakhpur, Mallika, Mulgoa Deshi, Suvarnrekha, Thanking Amadi and Totapari Red Small, while, it was absent in rest of the mango varieties. Such variations in surface morphology might be due to the inherent nature of particular varieties and the prevailing agroclimatic conditions.

Data pertaining to the fruit weight of varieties is presented in Table 2. The results displayed that there was significant variation among different varieties. In the year 2012, the variety Haathijhool registered maximum fruit weight (1906.30 g) while, the minimum fruit weight (113.64 g) was found in Tamancha which was statistically *at par* with Totapari Red Small (118.36 g), Neelum (123.89 g) and Safeda Lucknow (125.11 g). In the following year, the variety Haathijhool recorded highest (1754.10 g) fruit weight. The minimum (119.58 g) fruit weight was observed in Tamancha which was found statistically *at par* with Totapari Red Small (114.35 g). Results pertaining to pooled data also proved that the fruit weight varied significantly and Haathijhool was the most superior variety in terms of fruit weight while Tamancha was found to be most inferior. The pooled data also revealed maximum fruit length (199.06 mm) in Haathijhool followed by Mallika, Langra Gorakhpur and Kesar (Basti), while, the minimum fruit length (65.06 mm) was found in Tamancha. Again in terms of fruit breadth, Haathijhool was found to be most superior followed by Bijoragarh (85.42 mm) and Mulgoa Deshi (82.47 mm) whereas, minimum (51.11 mm) fruit breadth was found in Husn-a-ra. These might be the result of alterations in absorption and translocation pattern of photosynthates, genetic composition and environmental factors. Abirami *et al.,* (2004), Bhuyan and Kobra (2007) and Kumar and Thakur (2011) reported similar variations.

The pulp stone ratio is an ideal parameter for judging the fruit quality from the consumer's point of view. The data regarding pulp: stone ratio of mango varieties (Table 3) revealed remarkable variation. The variety Haathijhool recorded highest pulp stone ratio during 2012 (10.60) as well as 2013 (10.30). It showed significant superiority over other varieties under evaluation. But, the initial year of study revealed minimum pulp: stone ratio (1.79) in variety Kesar (Basti) which was in contrast to the following year, which revealed lowest pulp stone ratio (1.89) in the variety K.O.-07. Mitra *et al.,* (2001) also found variation for pulp: stone ratio in mango varieties and concluded that a high pulp: stone ratio indicates the suitability of the cultivars for fruit processing. Waste index of mango varieties also varied significantly and pooled analysis of data showed significantly highest waste index (5.27) in variety Haathijhool followed by Mallika (4.29) whereas, the minimum waste index (0.74) was recorded in variety Kesar (Basti). Similar studies were also performed by Sinha *et al.,* 2007a who found highest non-edible ratio in variety Mallika.

The fibre content per cent and lenticels density, in the present study, indicated striking variation (Table 3). The variety Haathijhool was adjudged as most fibrous throughout the entire course of study. It possessed maximum fibre per cent (5.27 % and 5.43 %) during both the years of study. The pooled results also indicated maximum fibre content (5.35 %) in Haathijhool followed by Bara Malda (3.01 %) and Rahman Pasand (3.68 %), while, minimum (0.62 %) was observed in Kaitki Bihar which was *at par* with Totapari Red Small (0.72 %), Rumani (0.77 %) and Gulabkhas Green (0.79 %). Lenticels are macro-pores on the mango fruit surface which play an important role in

gaseous exchange. The study indicated that during 2012, the maximum lenticels density was observed in variety Rumani (49.57) which, was followed by Husn-a-ra (34.66), Pulgoa Darbhanga (32.50), Chausa (31.86) and Zafrani Gola (31.71) while, the minimum lenticel density was recorded in variety Khas-ul-Khas (6.52). The subsequent year also revealed analogous trend. Again, the pooled analysis of data obtained during 2012 and 2013 also, revealed highest (55.57) and lowest (7.02) lenticels density in variety Rumani and Khas-ul-Khas, respectively. In line with these results, Dietz *et al.,* (1989) and Paul *et al.,* (2007) also studied the differences in cultivars for lenticels density on mango fruit surface.

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