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Assessment of physiological changes in mango fruit at different stages of growth and development

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Abstract
The present investigation was conducted on ten varieties of mango collected from orchard at Mahatma Phule Krishi Vidyapeeth, Rahuri. This study aimed at understanding the physical characteristics of mango varieties. Parameters like length, diameter, weight, volume and specific gravity varied according to varieties. Fruit length, diameter, weight, volume increased from mustard to mature stage but then slightly decreased at ripe stage. Cultivar Sai Sugandh recorded maximum length at marble stage (3.28 cm), egg stage (8.10 cm), mature stage (18.83 cm) and ripe stage (18.77 cm) of growth. Cultivar Rajapuri reported maximum diameter at marble stage (2.14 cm), egg (5.83 cm), mature (12.93 cm) and ripe stage (12.87 cm). Cultivar Rajapuri reported maximum fruit weight at egg stage (85.33 g), mature stage (603.00 g) and ripe stage (594.00 g). Vanraj recorded maximum fruit volume at marble stage (7.77 ml) and egg stage (81.83 ml). Rajapuri recorded maximum volume at mature stage (593.33 ml) and at ripe stage (586.67 ml). Maximum specific gravity was noticed at maturity of fruit and it was either 1.02 or 1.03. In ripe stage it was ranged from 1.01 to 1.02.

Keywords: Physiological, growth and development, quality, mango

Introduction
Mango is called as king of the fruits (Purseglove, 1972) [9]. Its cultivation is as old as Indian civilization. Fruit development is series of complex physiological, biochemical processes. The number of investigations on basic questions concerning the growth and development of fruits are meagre in comparison with those on other aspects of plant growth. The time it takes for the fruit to fully grow and mature varies by variety and area as well as the methodologies used to determine the rate of development. Mangoes are climacteric, meaning they ripen after being picked. The physical attributes *viz.* fruit weight, colour, pulp, taste, pulp contents, stone and pulp contents of the mango are used to judge the maturity indices and harvesting stages on mango. (Hamdard *et al*. 2004) [6]. The physical and chemical changes that the mango fruit undergoes during its growth have been used to identify the optimal harvesting date for immediate consumption or preservation. The physiological characteristics of mango cultivars are critical in determining their performance. With a view understand the physical changes in mango at different stages of growth and development, the present investigation entitled "Assessment of physiological changes in mango fruit at different stages of growth and development" was conducted in ten cultivars of mango.

Material and methods
Ten varieties of mango fruit namely Sai Sugandh, Kesar, Alphonso, Mallika, Vanraj, Totapuri, Ratna, Pairi, Neelum and Rajapuri were used as experimental material which were collected at different stages such as mustard, pea, marble, egg, mature and ripe stages from the Instructional cum Research farm, Department of Horticulture, MPKV, Rahuri, Dist. Ahmednagar during the year 2020-2021. The experiment was conducted in Randomized Block Design (RBD) with three replications and ten cultivars as treatments. Earlier selected fruit of ten mango cultivars at each stage of growth and development from tagged panicle of each replication were washed with distilled water. The parameters like length and diameter measured with the help of a Vernier Caliper and expressed in centimeter (cm). Collected fruit were weighed on electronic weighing balance and expressed in grams (g). The volume of selected mango fruit was measured by water displacement method. Specific gravity calculated by dividing weight by volume of fruit.

Result and discussion

There was no significance difference observed in length of mustard and pea stages of mango varieties. However cultivar Sai Sugandh recorded maximum length at marble stage (3.28 cm), egg stage (8.10 cm), mature stage (18.83 cm) and ripe stage (18.77 cm) of growth. While Neelum showed minimum length at marble stage (2.14 cm), Pairi at egg stage (6.57 cm), mature stage (12.33 cm) and ripe stage (12.20 cm). There was gradual increase in fruit length from mustard to mature stage and slight decrease at ripe stage of mango varieties. Banik and Sen (2004) [4] observed that the length increased until maturity but later decreases at ripe stage in different varieties of mango.

There was no significant difference observed among the diameter of fruit at mustard stage but diameter was differ significantly at pea, mustard, egg, mature and ripe stages in different varieties of mango. At pea stage maximum fruit diameter was observed in Vanraj (0.97 cm). Cultivar Rajapuri reported maximum diameter at marble stage (2.14 cm), egg (5.83 cm), mature (12.93 cm) and ripe stage (12.87 cm) while minimum diameter was noticed in Pairi at pea stage (0.58 cm), in Neelum at marble (1.16 cm), in Alphonso at egg (3.47 cm), Neelum at mature (8.63 cm) and ripe (8.57 cm) stage of growth. Data clearly indicated that the fruit diameter was progressively increased with the advancement of time up to mature stage and slightly decreased at ripe stage. Chatterjee *et al*. (2005) [5] and Aktar (2013) [1] reported that diameter of mango fruit varied according to varieties at different stages of growth and development.

Weight of fruit at mustard stage was not influenced significantly by varieties but at pea, marble, egg, mature and ripe stage it was significantly influenced by varieties at different stages of growth and development. At pea stage maximum fruit weight was noticed in cultivar Rajapuri (0.57g), however at marble stage maximum fruit weight was observed in Vanraj (7.00 g), Cultivar Rajapuri reported maximum fruit weight at egg stage (85.33 g), mature stage (603.00 g) and ripe stage (594.00 g). While minimum fruit weight was observed in Sai Sugandh at pea (0.33 g) and marble (5.13 g) stage of growth. Alphonso at egg stage (67.00 g), Neelum at mature stage (246.68 g) and Pairi at ripe stage (225.71 g). There was an increase in fruit weight from mustard to mature stage, which later on decreased slightly at ripe stage in all the mango cultivars. This may be due to hydrolysis of starch, as starch accumulation increases fruit weight (Lechaudel, 2005) [8].

Fruit volume of different mango cultivars at mustard stage was observed non-significant but noticed significant difference in fruit volume at pea, marble, egg, mature and ripe stages of different mango cultivars. At pea stage maximum fruit volume was recorded in Totapuri and Rajapuri (0.67 ml, each). Vanraj recorded maximum fruit volume at marble stage (7.77 ml) and egg stage (81.83 ml). Rajapuri recorded maximum fruit volume at mature stage (593.33 ml) and at ripe stage (586.67 ml). While minimum fruit volume was observed in Sai Sugandh at pea stage (0.43 ml), at marble stage (6.17 ml) in Neelum, at egg stage (71.33 ml) in Alphonso and at mature stage (238.33 ml) and ripe stage (231.67 ml) in Neelum, there was gradual increase in fruit volume from mustard to mature stage but then it was slightly reduced at ripe stage. Similar results also reported by Badhe *et al.* (2007) [2].

At different growth stages of fruit, there was no significant difference amongst the variety in respect to specific gravity was noticed. Amongst the ten varieties of mango the specific gravity ranged from 0.73 to 0.91 at mustard stage, while at pea stage it was varied from 0.71 to 0.85 and when the fruit attended the marble size it was in between 0.82 to 0.91. In case of egg stage specific gravity was found to be ranged from 0.93 to 0.97. Maximum specific gravity was noticed at maturity of fruit and it was either 1.02 or 1.03. Similarly, at ripe stage, very less difference was recorded in specific gravity of mango fruit and it was either 1.01 or 1.02. According to Kapse and Katrodia (1997) [7], mango fruit with a specific gravity of 1 to 1.02 were determined to be at the peak of ripeness.

Table 1: Length of mango fruit at different stages of growth and development (cm)

Tr. No.	Stage/Variety	Mustard	Pea	Marble	Egg	Mature	Ripe
T_1	Sai Sugandh	0.24	1.15	3.28	8.10	18.83	18.77
T_2	Kesar	0.24	1.09	2.48	7.23	14.67	14.53
T_3	Alphonso	0.25	1.05	2.37	7.19	13.10	13.03
T_4	Mallika	0.24	1.15	2.76	7.73	16.53	15.43
T_5	Vanraj	0.25	1.16	2.97	7.77	15.60	16.47
T_6	Totapuri	0.22	1.17	3.16	7.80	17.67	17.53
T_7	Ratna	0.24	1.02	2.47	7.10	13.47	13.13
T_8	Pairi	0.24	0.99	2.35	6.57	12.33	12.20
T_9	Neelum	0.25	1.08	2.14	6.84	12.73	12.67
T_{10}	Rajapuri	0.25	1.23	2.73	7.63	14.97	14.87
	SE(m)±	0.01	0.05	0.10	0.14	0.23	0.29
	CD at 5%	NS	NS	0.28	0.40	0.69	0.87

Table 2: Diameter of mango fruit at different stages of growth and development (cm)

Tr. No.	Stage/Variety	Mustard	Pea	Marble	Egg	Mature	Ripe
T_1	Sai Sugandh	0.21	0.81	1.77	4.87	10.23	10.17
T_2	Kesar	0.19	0.84	1.68	4.55	9.77	9.67
T_3	Alphonso	0.21	0.91	1.62	3.47	9.34	9.20
T_4	Mallika	0.20	0.80	1.75	4.69	10.10	10.07
T_5	Vanraj	0.21	0.97	2.00	5.55	12.80	12.70
T_6	Totapuri	0.23	0.90	1.86	5.37	11.30	11.10
T_7	Ratna	0.19	0.81	1.89	4.90	10.45	10.32
T_8	Pairi	0.19	0.58	1.57	4.67	8.70	8.67
T_9	Neelum	0.20	0.72	1.16	4.53	8.63	8.57

T_{10}	Rajapuri	0.22	0.88	2.14	5.83	12.93	12.87
	SE(m)±	0.00	0.05	0.42	0.37	0.21	0.11
	CD at 5%	NS	0.14	0.43	1.11	0.61	0.33

Table 3: Weight mango fruit at different stages of growth and development (g)

Tr. No.	Stage/Variety	Mustard	Pea	Marble	Egg	Mature	Ripe
T_1	Sai Sugandh	0.030	0.33	5.13	77.47	429.67	414.33
T_2	Kesar	0.030	0.40	5.70	75.20	315.00	301.00
T_3	Alphonso	0.027	0.40	5.57	67.00	273.67	265.00
T_4	Mallika	0.033	0.50	6.27	78.40	543.33	535.67
T_5	Vanraj	0.035	0.50	7.00	85.03	550.00	538.33
T_6	Totapuri	0.036	0.53	5.80	84.30	443.33	430.38
T_7	Ratna	0.033	0.40	6.50	76.60	429.67	411.00
T_8	Pairi	0.032	0.37	5.50	67.37	248.68	225.71
T_9	Neelum	0.035	0.40	5.30	73.34	246.67	236.66
T_{10}	Rajapuri	0.037	0.57	6.73	85.33	603.00	594.00
	SE(m)±	0.003	0.04	0.35	1.50	26.59	31.05
	CD at 5%	NS	0.13	1.04	4.45	79.00	92.25

Table 4: Volume mango fruit at different stages of growth and development (ml)

Tr. No.	Stage/Variety	Mustard	Pea	Marble	Egg	Mature	Ripe
T_1	Sai Sugandh	0.035	0.43	6.23	81.30	420.00	409.67
T_2	Kesar	0.037	0.57	6.40	79.57	310.00	296.00
T_3	Alphonso	0.037	0.53	6.60	71.33	266.67	260.33
T_4	Mallika	0.036	0.60	7.17	82.10	533.67	528.00
T_5	Vanraj	0.040	0.63	7.77	88.83	535.33	533.00
T_6	Totapuri	0.040	0.67	6.77	88.60	430.00	426.00
T_7	Ratna	0.037	0.53	7.17	82.03	416.33	405.00
T_8	Pairi	0.036	0.50	6.50	72.23	242.68	244.00
T_9	Neelum	0.039	0.53	6.17	77.83	238.33	231.67
T_{10}	Rajapuri	0.040	0.67	7.70	88.33	593.32	586.67
	SE(m)±	0.003	0.05	0.33	1.69	28.79	33.11
	CD at 5%	NS	0.14	0.97	5.02	85.55	98.37

Table 5: Specific gravity of different mango varieties at different stages of growth of fruit

Tr. No.	Stage/Variety	Mustard	Pea	Marble	Egg	Mature	Ripe
T_1	Sai Sugandh	0.87	0.78	0.82	0.95	1.02	1.01
T_2	Kesar	0.82	0.71	0.89	0.94	1.02	1.02
T_3	Alphonso	0.73	0.74	0.85	0.94	1.03	1.02
T_4	Mallika	0.91	0.83	0.88	0.96	1.03	1.01
T_5	Vanraj	0.86	0.79	0.90	0.96	1.02	1.01
T_6	Totapuri	0.90	0.80	0.86	0.95	1.03	1.01
T_7	Ratna	0.89	0.75	0.91	0.93	1.03	1.01
T_8	Pairi	0.90	0.74	0.85	0.93	1.03	1.02
T_9	Neelum	0.89	0.76	0.86	0.94	1.03	1.02
T_{10}	Rajapuri	0.91	0.85	0.87	0.97	1.02	1.01
	SE(m)±	0.04	0.05	0.04	0.01	0.01	0.00
	CD at 5%	NS	NS	NS	NS	NS	NS

Conclusions

From the above experiment it can be concluded that the physiological parameters varies according to varieties and stages. The parameters like length, diameter, weight and volume increased from mustard to mature stage and slightly decreased from mature to ripe stage. No significant difference was noticed in specific gravity at different stages of fruit growth but at mature and ripe stage it ranged in between 1.01-1.03. These kinds of studies will help to characterization of cultivars. From any experimental results obtained from a single year study is not sufficient to draw a valid conclusion. So the same experiment should be repeated under the same environment for further verification of the results.

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