



Determination of maturity indices for harvesting of pomegranate (*Punica granatum*)

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Received: 17 October 2016; Accepted: 05 May 2017

ABSTRACT

Pomegranate (*Punica granatum* L.) is an important fruit crop of arid and semiarid regions of the world with immense medicinal and nutritional value. Bhagwa, Ruby, Ganesh, G-137, Jalore Seedless, Arakta and Mridula are some of the popular cultivars of pomegranate which are commercially cultivated in different parts of India. These varieties differ in their maturity period (time taken from full bloom to harvest). Harvesting the fruits of pomegranate too early does not allow fruits to ripen properly while late harvesting limits the market life of fruits. Hence, an experiment was conducted to determine the appropriate maturity indices for harvesting pomegranate during 2011-12 and 2012-2013. Days after full bloom (DAFB), fruit weight, fruit length, fruit diameter, 100 arils weight, TSS, titrable acidity and brix-acid ratio (BAR) were recorded at 15 days interval after fruitset. The maturity indices, viz. total soluble solids (TSS) and brix-acid ratio determined for harvesting the fruits of pomegranate with better edible quality is as follows: ie. 15.95°B TSS and 31.90 BAR at 180 DAFB for Bhagwa, 15.80°B TSS and 32.91 BAR at 175 DAFB for Ruby, 16.10°B TSS, 37.44 BAR at 150 DAFB for Ganesh, 16.20°B TSS, 36.00 BAR at 145 DAFB for Jalore Seedless, 15.40°B TSS, 34.22 BAR at 140 DAFB for Arakta and 15.50°B TSS, 33.69 BAR at 140 DAFB for Mridula.

Key words: Brix-acid ratio (BAR), Harvesting, Maturity indices, Physico-chemical parameters, Pomegranate

Pomegranate (*Punica granatum* L.) is an important fruit crop of arid and semiarid regions of the world with immense medicinal and nutritional value (Pal and Babu 2015). It's a diploid ($2n=2x=16$) perennial shrub from the family Lythraceae (sub-family: Punicoideae). The versatile adaptability and built-in drought tolerance paves the way for its sustainability under marginal lands. It is believed to have originated from Iran and highly adapted to climatic conditions of India, In India, it is cultivated over 131 000 ha with a production of 13 46 000 tonnes/annum and a productivity of 10.27 tonnes/ha during 2013-14 (NHB 2014). Bhagwa, Ruby, Ganesh, G-137, Jalore Seedless, Arakta and Mridula are some of the popular cultivars of pomegranate which are commercially cultivated in different parts of India (Jadhav and Sharma 2007). Bhagwa has become the predominant cultivar occupying major area under cultivation with attractive red skin, deep red arils, soft seeds (mellowness) and huge export demand. Varieties

like Ruby, Arakta and Mridula also have red arils, whereas Ganesh, G-137 and Jalore Seedless have pink arils. As these varieties have huge demand in domestic market, their cultivation has been taken up on commercial scale.

India is the only country in the world where pomegranate fruits are available throughout the year (January- December). It is due the prevailing climatic conditions in the Deccan Plateau regions of India where it is cultivated during ambe bahar, mrig bahar and hath bahar. Besides climatic condition, the varietal wealth of pomegranate also contributes for its year round availability. India has both cultivated varieties and wild varieties, viz. Daru growing naturally under Himalayan mountain ranges. The cultivated varieties vary in their maturity period (ie. time taken from flowering to harvesting).

The maturity has been divided into two categories, viz. physiological maturity and harvest maturity. Physiological maturity is the stage when a fruit is capable of further development or ripening when it is harvested, ie. ready for eating or processing. Harvest maturity refers to the stage of development when plant and plant part possesses the prerequisites for use by consumers for a particular purpose, i.e. ready for harvest. Determination of maturity indices help ensure sensory quality (flavor, colour, aroma and texture) and nutritional quality, ensure an adequate shelf-life, facilitate scheduling harvest and packing operations besides

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facilitating marketing over the phone or through internet.

Fruits harvested too early may lack flavour and may not ripen properly. Being 'non-climacteric' crop, the fruits of pomegranate should be harvested once they attain maturity in the plant itself (Pal and Babu 2014, Gaikwad *et al.* 2014). At the same time late harvesting should be avoided as it limits the market life of fruits and increases the incidence of physiological disorder, Internal Breakdown. So, it is essential to harvest the fruits of pomegranate at right stage of maturity to ensure better quality and optimum market life of harvested fruits. As the varieties differ in their maturity period, it becomes indispensable to determine the maturity indices for different cultivars. Hence, an experiment was conducted with the objective of determining the maturity indices for harvesting of commercial cultivars of pomegranate.

MATERIALS AND METHODS

The experiment was undertaken at the Hiraj Experimental Farm of ICAR-National Research Centre on Pomegranate, Solapur during 2011-12 and 2012-13. Seven commercial cultivars of pomegranate planted during December 2009 were chosen for the study. They were planted at a standard distance of 4.5×3.0 m spacing. These cultivars encompass Bhagwa, Ruby, Ganesh, G-137, Jalore Seedless, Arakta and Mridula. The crop regulation was done during *mrig bahar* by withholding the water during January-February months. Standard practices of bahar treatment, viz. pruning, defoliation, manuring, etc were done during last week of May. About 450 flowers were tagged in each cultivar (i.e. 30 flowers/tree/cultivar) during anthesis when flower buds open completely. Fruit samples (10 fruits/replication/cultivar) were drawn after fruitset regularly at 15 days interval for physico-chemical analysis. The fruit samples were drawn for three replications. During the

end of maturity, the fruit samples were drawn at narrow interval of 3-5 days period so as to fix up the appropriate maturity indices under Solapur conditions. Fruit weight was recorded using the electronic weighing scale. Fruit length and diameter, aril length and aril diameter were recorded using digital Vernier caliper. 100 aril weight was recorded by counting the randomly selected arils and weighing in a precision electronic balance. Total soluble solids content (TSS) was measured using Digital Refractometer by placing a drop of juice on the prism which indicate how much a light beam will be slowed down when it passes through the fruit juice and recorded as °Brix. The titratable acidity was determined through titration against 0.1N NaOH using phenolphthalein indicator (Ranganna 1978). Brix-acid ratio was determined by dividing the TSS with Titratable acidity. The statistical analysis was carried out by following the standard procedure (Panse and Sukhatme 1985).

RESULTS AND DISCUSSION

A perusal of data given in Fig 1, revealed that the fruit weight increased rapidly from 15 days after full bloom to 135 days after full bloom (DAFB). The increase in fruit weight has been manifested 2 distinct phases; A rapid phase of increase in fruit weight commencing from 15 DAFB (ie. up to 135 DAFB for Bhagwa and Ruby; up to 105 DAFB for G-137, Jalore Seedless, Arakta and Mridula).

In case of Bhagwa, the fruit weight increased up to 180 DAFB (313.33g/fruit), whereas beyond 180 DAFB, the fruit weight remained almost constant. Similarly, the increase in fruit weight was witnessed up to 175 DAFB in case of Ruby beyond which the increase in fruit weight was negligible. The increase in fruit weight was statistically significant up to 150 DAFB for Ganesh, 148 DAFB for G-137, 145 DAFB for Jalore Seedless and 140 DAFB for Arakta and Mridula.

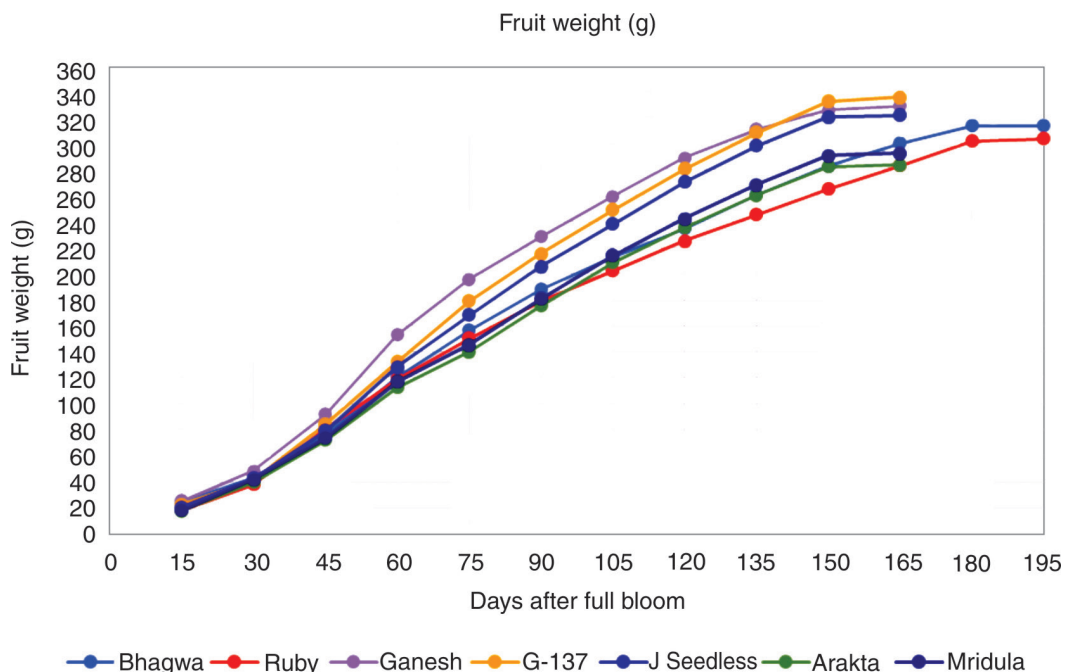


Fig 1 Fruit weight (g) of pomegranate cultivars during the fruit growth and development

Table 1 Fruit length (mm) of pomegranate in different cultivars

Stage of fruit development (DAFB)*	Cultivars		Stage of fruit development (DAFB)*	Cultivars				
	Bhagwa	Ruby		Ganesh	G-137	J. Seedless	Arakta	Mridula
15	34.89	24.11	15	28.16	29.67	33.95	32.12	29.09
30	52.34	47.78	30	43.24	44.31	47.56	40.51	43.59
45	56.57	52.26	45	61.17	58.77	60.39	50.60	50.75
60	64.64	57.89	60	65.15	64.38	64.02	58.20	59.10
75	68.11	63.90	75	68.44	71.21	70.34	66.51	65.40
90	69.50	66.45	90	75.14	72.63	72.60	68.53	68.33
105	71.72	68.10	105	77.06	76.24	74.24	70.20	70.20
120	73.70	70.84	120	79.83	79.30	76.83	72.81	72.55
135	75.12	72.52	135	81.02	81.82	80.15	74.00	74.38
150	78.11	74.47	140+	84.61	85.24	83.16	76.19	75.20
165	80.08	76.24	145+	84.63	85.26	83.20	76.20	75.28
175+	82.56	77.40	LSD (P=0.05)	3.90	4.16	3.80	2.80	2.40
195	82.56	77.50						
LSD (P=0.05)	3.79	3.76						

* :175+ refers 180 DAFS for Bhagwa and 175 DAFS for Ruby; 140+ refers 150 DAFS for Ganesh,148 DAFS for G-137, 145 DAFS for J. Seedless and 140 DAFS for Arakta and Mridula;145+ refers 155 DAFS for Ganesh,150 DAFS for G-137, 150 DAFS for J. Seedless and 145 DAFS for Arakta and Mridula.

Beyond this stage of fruit development, the increase in fruit weight was meagre and negligible. This is in corroboration with the findings of Prasad *et al.* (2000) who also reported linear increase in fruit weight from fruit set to harvest.

A perusal of data given in Table 1 revealed that the fruit length increased at a faster rate from 15 days after fruitset to 135 days after harvest. The increase in fruit length has manifested 2 distinct phases; a rapid phase of increase in fruit length commencing from 15 DAFB (ie. up to 135 DAFB for Bhagwa and Ruby; up to 105 DAFB for G-137, Jalore Seedless, Arakta and Mridula). In case of Bhagwa, the fruit length increased up to 180 DAFB (82.56mm), whereas beyond 180 DAFB, the fruit length remained almost constant. Similarly, the increase in fruit length was witnessed up to 175 DAFB in case of Ruby, beyond which the increase was negligible.

The increase in fruit length was statistically significant up to 150 DAFB for Ganesh, 148 DAFB for G-137, 145 DAFB for Jalore Seedless and 140 DAFB for Arakta and Mridula. Beyond this stage of fruit development, the increase in fruit weight was almost nil. This is in line with the findings of Sulman *et al.* (1984) who also established a linear relationship between fruit length and days after fruitset. Khodade *et al.* (1999) also reported a similar result in pomegranate.

A perusal of data given in Table 2 revealed that the fruit diameter increased rapidly from 15 days after fruit set to 135 days after harvest. The increase in fruit diameter has manifested 2 distinct phases; a rapid phase of increase in fruit diameter commencing from 15 DAFB (ie. up to 135 DAFB for Bhagwa and Ruby; up to 105 DAFB for G-137, Jalore Seedless, Arakta and Mridula). In case of Bhagwa,

the fruit diameter increased up to 180 DAFB (83.59mm), whereas beyond 180 DAFB, the fruit diameter remained almost constant. Similarly, the increase in fruit diameter was witnessed up to 175 DAFB in case of Ruby, beyond which the increase was negligible.

The increase in fruit diameter was statistically significant up to 150 DAFB for Ganesh, 148 DAFB for G-137, 145 DAFB for Jalore Seedless and 140 DAFB for Arakta and Mridula. Beyond this stage of fruit development, the increase in fruit diameter was almost nil. Prasad *et al.* (2000) also reported a similar results during the fruit growth and development of pomegranate cultivar Jalore Seedless. Similar results were also reported by Godara *et al.* (1989) and Bankar *et al.* (1992).

It was revealed that 100 aril weight is an important trait in determining the aril size (boldness of arils). In Bhagwa, the 100 aril weight increased from 3.99g on 15 DAFB to 34.03g on 180 DAFB. The 100 aril weight increased significantly from 15 DAFB to 180 DAFB. Beyond 180 days, there was a slight decrease in the 100 aril weight which indicates the crossing of the maturity stage (ie. over-mature). Similarly, the 100 aril weight was maximum (32.00g) on 175 DAFB in case of Ruby variety.

The 100 aril weight attained its peak value on 150 DAFB for Ganesh (25.84g), 148 DAFB for G-137 (28.84g), 145 DAFB for Jalore Seedless (28.80g), and 140 DAFB for Arakta (30.25g) and Mridula (30.60g). This is in corroboration with the findings of Babu *et al.* (2014) who studied the relationship between 100 aril weight and days after full bloom.

Total soluble solids (Fig 2) content of pomegranate varieties manifested an upward trend during the fruit growth

Table 2 Fruit diameter (mm) of pomegranate in different cultivars

Stage of fruit development (DAFB)*	Cultivars		Stage of fruit development (DAFB)*	Cultivars				
	Bhagwa	Ruby		Ganesh	G-137	J. Seedless	Arakta	Mridula
15	33.52	21.89	15	26.92	28.68	30.99	30.33	27.69
30	50.28	38.48	30	38.74	42.41	39.46	38.16	39.24
45	52.66	50.49	45	57.95	54.34	56.67	49.06	48.56
60	65.19	59.89	60	66.32	63.20	63.31	60.08	59.37
75	67.04	63.06	75	67.58	69.62	67.02	66.35	64.80
90	68.71	65.44	90	74.93	72.08	71.26	68.05	70.94
105	70.90	67.40	105	78.20	78.12	74.60	72.84	72.64
120	72.86	69.43	120	81.08	80.82	79.98	73.73	75.71
135	74.86	71.52	135	83.45	82.01	82.21	75.38	77.54
150	77.05	76.10	140+	86.70	86.48	84.32	78.86	79.10
165	80.75	78.00	145+	86.74	86.48	84.34	78.86	79.14
175+	83.59	79.28	CD(P=0.05)	1.12	1.52	1.10	1.04	1.62
185	83.59	79.30						
CD(P=0.05)	1.04	1.12						

*175+ refers 180 DAFS for Bhagwa and 175 DAFS for Ruby; 140+ refers 150 DAFS for Ganesh, 148 DAFS for G-137, 145 DAFS for J. Seedless and 140 DAFS for Arakta and Mridula; 145+ refers 155 DAFS for Ganesh, 150 DAFS for G-137, 150 DAFS for J. Seedless and 145 DAFS for Arakta and Mridula.

and development. The TSS increased from 15 DAFB to its peak value during advancement of fruit maturity. In Bhagwa, the TSS increased from 8.22°B on 15 DAFB to 16.48°B on 180 DAFB. The TSS increased significantly from 15 DAFB to 180 DAFB. Beyond 180 days, there was a slight decrease in the TSS which indicates the crossing of the maturity stage (ie. over-mature). Similarly, the TSS attained its peak value (15.80°B) on 175 DAFB in case of Ruby variety. The TSS attained its peak value on 150 DAFB for Ganesh (16.7°B), 148 DAFB for G-137(16.7°B), 145 DAFB for Jalore Seedless (16.12°B), and 140 DAFB for Arakta (15.36°B) and Mridula (15.48°B). Similar findings were

also reported by Mir *et al.* (2012). This is in corroboration with the findings of Ben-Arie *et al.* (1984).

During fruit growth and development, the titrable acidity (TA) content of pomegranate juice was found to exhibit a downward trend. The TA was highest on 15 DAFB. With the advancement of fruit growth and development, the titrable acidity decreased. In Bhagwa, the TA decreased from 0.64% on 15 DAFB to 0.51% on 180 DAFB. The TA manifested a downward trend and reached its lowest value on 180 DAFB. Beyond 180 days, the TA was found to be static. Similarly, the TA attained its lowest value (0.47%) on 175 DAFB in case of Ruby variety. The TA attained its

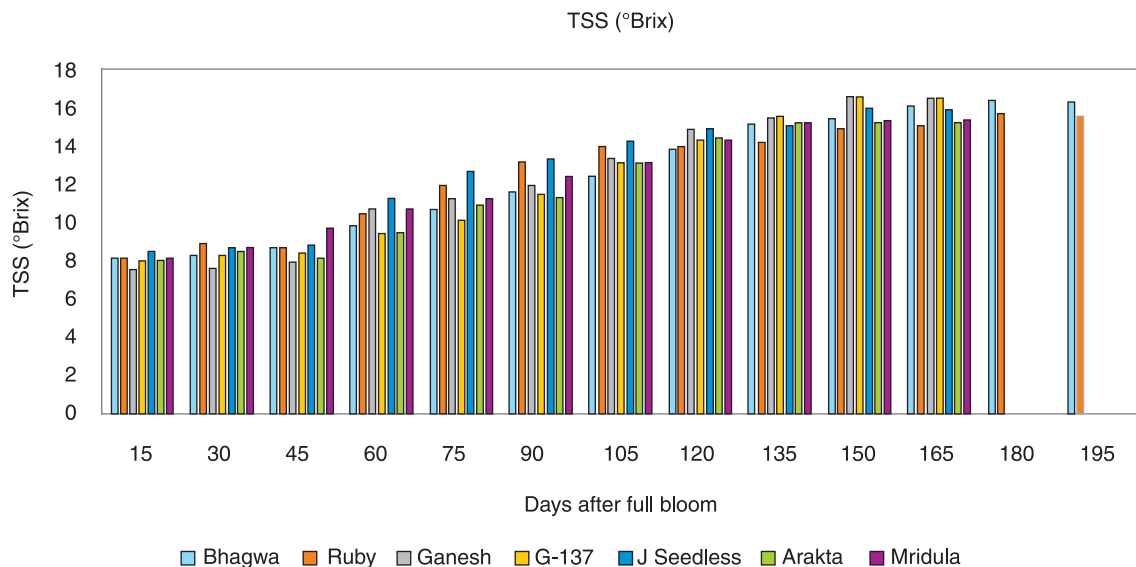


Fig 2 Total Soluble Solids (g) of pomegranate in different cultivars

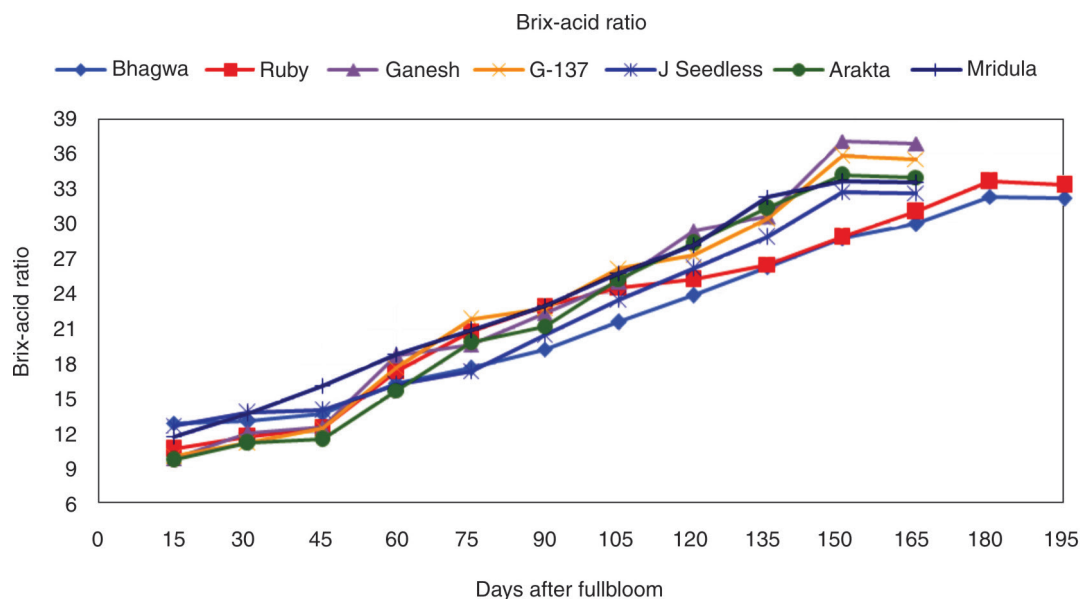


Fig 3 Brix-acid ratio of pomegranate in different cultivars

Table 3 Maturity indices for harvesting of pomegranate cultivars

Characteristics	Bhagwa	Ruby	Ganesh	G-137	J. Seedless	Arakta	Mridula
Days after full bloom (days)	180	175	150	148	145	140	140
100 aril weight (g)	34.03	32.00	25.84	28.84	28.80	30.25	30.60
TSS (°B)	15.95	15.80	16.10	16.20	16.30	15.40	15.50
Titrate acidity (%)	0.50	0.48	0.43	0.45	0.43	0.45	0.46
TSS/acid ratio	31.90	32.91	37.44	36.00	37.90	34.22	33.69

lowest value on 150 DAFB for Ganesh (0.45%), 148 DAFB for G-137(0.45%), 145 DAFB for Jalore Seedless (0.51%), and 140 DAFB for Arakta (0.45%) and Mridula (0.46%). This is in line with the findings of Mir *et al.* (2007) and Babu *et al.* (2014).

The TSS acid ratio is often better related to palatability of fruit than either sugar or acid level alone. The brix acid ratio (BAR) of pomegranate varieties manifested an upward trend during the fruit growth and development. The BAR increased from 15 DAFB till it attains its peak value during advancement of fruit maturity. In Bhagwa, the BAR increased from 12.84 on 15 DAFB to 32.31 on 180 DAFB. The BAR increased significantly from 15 DAFB to 180 DAFB. Beyond 180 days, there was a slight decrease in the BAR which indicates the crossing of the maturity stage (ie. over-mature). Similarly, the BAR attained its peak value (33.61) on 175 DAFB in case of Ruby variety. The BAR attained its peak value on 150 DAFB for Ganesh (37.11), 148 DAFB for G-137(35.82), 145 DAFB for Jalore Seedless (32.74), and 140 DAFB for Arakta (34.12) and Mridula (33.65). This is in confirmation with the findings of Ben-Arie *et al.* (1984) in pomegranate.

The maturity indices for harvesting the fruits of pomegranate cultivars under Solapur conditions of Maharashtra are tabulated in Table 3.

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