



PERFORMANCE OF POMEGRANATE (*Punica granatum* L.) CULTIVARS FOR GROWTH, YIELD AND PHYSICO-CHEMICAL TRAITS UNDER KAREWA EDAPHOLOGICAL CONDITIONS IN TEMPERATE CLIMATE OF KASHMIR VALLEY

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ABSTRACT

Eight varieties of pomegranate were evaluated under Karewa condition of Kashmir valley at Central Institute of Temperate Horticulture (CITH), Srinagar, for five years i.e. from 2006-07 to 2009-10, The Cultivar 'Bedana' had maximum plant spread followed by 'Chawla', 'Jyoti' and, 'Dholka'. The plant height in 'Chawla' was significantly more compared to other cultivars. The maximum number of fruit per tree, fruit set, fruit size, fruit length, fruit calyx diameter, fruit weight, fruit volume, yield/tree, TSS, ascorbic acid, acidity, total chlorophyll content and minimum aphid attack recorded in 'Dholka'. The cultivar 'Kandhari' was found superior in reducing sugar, and total sugar. However, cultivar 'Jyoti' was better in bloom period, number of Seed + Aril, minimum fruit cracking, anar butterfly attack. Fruit L/D ratio was found highest in 'Chawla', and maturity index highest in cultivar 'Mridula'. The local variety of region 'Kashmir Local' was also found better in juice pH 46 and shelf life at ambient condition 65.26 days.

Key Words : Pomegranate, performance, Karewa condition, vegetative growth, fruit morphology physico-chemical properties and yield.

Pomegranate has been traditionally cultivated since ancient times under diverse agro-climatic conditions (Evreinoff 1949). The production and consumption of pomegranate fruits around the whole world is increasing rapidly. The fact that pomegranate fruit has a number of industrial usage, like fruit juice, conserve, vinegar, citric

acid and medicine, lead to its gaining popularity in the world markets (Cemeroglu, 1977, Dokuzoguz and Mendilcioglu, 1978 and Aviram and Dornfeld, 2001). The calorific value of fruit is 65 and juice is easily digestible which contains about 15 per cent invert sugar. Fruit is also a rich source of sodium (3 mg), riboflavin

(0.012-0.03 mg), thiamin (0.003 mg), niacin (0.180-0.3 mg), vitamin-C (4-4.2 mg), calcium (3-12 mg) and phosphorous (8-37 mg) per 100 gm of edible portion. As a cultivated crop the pomegranate is grown in many states of India like Maharashtra, Gujarat, Rajasthan, Uttar Pradesh, Haryana, Andhra Pradesh, Karnataka and Tamilnadu and to a limited extent in Jammu and Kashmir, Himachal and Uttarakhand. In India pomegranate is being cultivated in an area of 0.12 million ha, 0.85 million t production with productivity of 7.0 t/ha (NHB, 2008), mostly in subtropical and tropical regions. In sub-temperate and temperate regions of J&K, H.P. and Uttarakhand the area is very small due to less importance given to this non-traditional crop.

As the crop possess drought hardiness, offers immense potential to grow under marginal lands. As a result it is gaining popularity among farmers all over the country particularly in rain-fed area. Similarly a large area is also available in temperate climate which offers the ideal climatic conditions for commercial cultivation of high quality pomegranate. As it is evident that world best quality pomegranates are being produced from temperate climate of Afghanistan, which are being mostly exported and earning significant amount of foreign exchange. It has vast scope of growing in marginal areas like unfertile rainfed Karewa edaphological situations. Since all the cultivars of pomegranate were not performing equally well under temperate ecosystem with respect to yield and quality attributes but due to extremes of low temperature. Keeping in view the present investigation was carried out to assess the performance of different varieties and to select the suitable varieties for commercial cultivation under temperate ecosystem.

MATERIALS AND METHODS

A study was undertaken from during 2006 and 2010 to evaluate the performance of commercial varieties under temperate ecosystem at the research farm of Central Institute of Temperate Horticulture (CITH), Srinagar. The varieties viz., 'Mridula', 'Chawla', 'Dholka', 'Bedana', 'Kandhari', 'Jyoti', 'Kashmir Local' and 'G-137' periodically observed. Planting was done at the distance of 2.5 x 2.5 m during 2001 and

uniform cultural practices were provided for all cultivates. The experimental farm is situated at latitude of 34° 05' N and longitude of 74° 50' E at an altitude of 1640 m above the sea level. The weather parameters recorded during the growing season were viz., mean maximum temperature 19.63 °C, mean minimum 6.52 °C, rainfall 60.72 mm, relative humidity 58.35 % and evaporation 2.45 m. The soils of the experimental farm have soil 6.81 pH and electrical conductivity 0.36 dSm⁻¹. The observations were recorded on vegetative growth (plant spread, plant height, stem girth, duration of flower, no. of fruits/plant, fruit set %, chlorophyll %), fruit characteristics (fruit weight, fruit diameter, fruit length, fruit calyx length, diameter, fruit L/D ratio, fresh fruit firmness, rind thickness, seed hardness, aril color, acidity, ascorbic acid, reducing sugar, total sugar, juice content, maturity index (MI), TSS/Acid ratio and yield per tree. Total chlorophyll content measured by CL-01 chlorophyll content meter. Twenty fruits of each cultivar were individually analyzed for physical parameters. Fruits were weighted in the air on a Sartorius balance of accuracy of 0.001 g. Fruit volume was calculated by a liquid displacement method. The length and diameter of the fruit and calyx were measured with a Mitutoyo digital vernier caliper. The measurement of fruit length was made on the polar axis, i.e. between the apex and the end of stem. The maximum width of the fruit, as measured in the direction perpendicular to the polar axis, is defined as the diameter. After measuring the whole fruit size, the arils were manually separated from the fruits, and total arils and peel per fruit were measured as above. The measurements of the peel thickness were made using the Mitutoyo digital vernier calliper. Then the juices were analyzed for major chemical composition. The titrable acidity (TA) was determined by titration to pH 8.1 with 0.1M NaOH solution and expressed as g of citric acid per 100 g of juice (AOAC, 1984). The pH measurements were performed using a digital pH meter (Delux 101) at 22 °C. The total soluble solids (TSS) were determined with Atago digital refractometer calibrated using distilled water. Results were reported as °Brix at 22 °C. The total sugars were estimated according to the method described by Ranganna (2001).

Results were expressed as g per 100 g of juice. Ascorbic acid was determined by employing the method described by Ruck (1963). Results were expressed as mg per 100 g of juice. Fruit firmness measured using HP qualitest digital firmness tester. The data (average of 5 years) was statistically analyzed using RBD by Online Statistical Analysis Package (OPSTAT, Computer Section, CCS Haryana Agricultural University, Hissar).

RESULTS AND DISCUSSION

The pertaining to vegetative growth and fruit characters showed a significant difference between varieties (Table 1). Cultivar ‘Bedana’ had maximum plant spread 128.64 mm followed by ‘Chawla’ 127.23 mm, ‘Jyoti’ 126.35 mm and ‘Dholka’ 124.66 mm. The plant height 160.82 mm recorded in ‘Chawla’ was significantly more compared to other varieties; it is obvious from the data that, ‘Bedana’, ‘Chawla’, ‘Jyoti’ cultivars were more spreading type compared to other cultivars. Stem girth varied from 42.24 mm to 60.60 mm. The maximum stem girth recorded in ‘Dholka’ and lowest in ‘Kashmir Local’. These findings are general agreement with earlier findings of Mir *et al.*, (2007). Regarding flowering and fruit set duration of flowering (days) was longest in ‘Jyoti’ (101.26), ‘G-137’ (100.30) followed by ‘Dholka’ (98.16). The highest fruit set percentage recorded in ‘Dholka’ (60.34), ‘Bedana’ (59.56), and ‘Kandhari’ (43.07) as compared to ‘Kashmir local’ (27.58). The total number of fruits per tree ranged between 15.84-34.08 and maximum recorded in ‘Dholka’, while lowest in ‘Mridula’ variety. There were significant differences in average fruit diameter and weight of fruits over ‘Kashmir Local’ (Table 1). Cultivar Dholka recorded maximum fruit diameter 81.10 mm followed by ‘Bedana’ 77.03 mm, and ‘Kandhari’ 76.66 mm. The fruit length ranged from 61.16 mm in ‘Chawla’ to 79.13 mm in ‘Dholka’. Similarly, fruit L/D ration was varied from 1.133 in ‘Chawla’ to 1.003 in ‘Kashmir Local’. The minor deviation in size (diameter, length and volume) with respect to fruit weight may be due to variation in fruit form as sometimes they are obscurely ridged as observed by Nath and Randhawa (1959). Fruit calyx

Table 1 : Vegetative growth and physical properties of fruit of the eight pomegranate cultivars

Varieties	Plant spread (cm)	Plant height (cm)	Stem girth (mm)	Duration of flower (days)	Fruit set (%)	Fruit No. of fruit/tree	Fruit diameter (mm)	Fruit length (mm)	Fruit L/D Ratio	Fruit weight (gm)	Fruit Volume (ml)	Fruit Calyx length (mm)	Fruit Calyx x Dia. (mm)	Fresh fruit firmness index	Seed hardness	Aril color
Chawla	127.233	160.827	52.007	71.667	36.660	28.667	69.533	61.167	1.133	210.080	51.167	15.240	13.207	34.300	Hard	Red
Mridula	85.360	75.353	50.333	63.167	27.653	15.843	72.133	71.167	1.010	223.153	60.167	22.500	15.167	37.300	Soft	Red
Jyoti	126.353	125.427	51.387	101.267	31.233	22.337	75.653	74.167	1.013	234.040	63.633	21.000	13.413	48.300	Soft	Pinkish red
G-137	112.833	122.533	53.040	100.300	39.440	26.860	76.587	75.200	1.013	230.247	51.767	26.233	15.227	42.433	Soft	Pinkish
Dholka	124.660	130.533	60.600	98.167	60.340	34.080	81.107	79.133	1.017	252.147	79.647	28.360	19.220	36.400	Soft	Pinkish white
Bedana	128.640	124.860	49.347	93.167	59.560	33.273	77.033	76.167	1.007	242.087	69.167	24.200	16.227	37.267	Soft	Pink
Kandhar	119.253	128.477	55.573	87.267	43.077	30.450	76.660	75.233	1.013	245.613	75.167	22.067	17.227	49.167	Hard	Deep Pink
Local Kashmir	119.227	124.640	42.240	60.000	27.583	26.960	71.167	70.167	1.003	130.407	49.167	20.067	12.513	27.700	Hard	Pinkish
CD at 5%	0.020	0.117	0.626	0.636	0.031	1.092	0.634	70.167	0.008	70.655	0.393	0.267	0.191	N.S.	-	-
CV	0.010	0.053	0.684	0.426	0.043	2.261	0.478	0.051	0.425	18.083	0.356	0.673	0.706	21.183	-	-

length was recorded maximum in ‘Dholka’ followed by ‘Bedana’ and ‘Kandhari’ while fruit calyx diameter ranged from minimum 12.52 mm in ‘Kashmir Local’ to maximum 19.23 mm in ‘Dholka’. Valero and Ruiz-Altisent (2000) have reported this knowledge is particularly relevant in the design or selection of appropriate packaging for fruit handling and storage. As regard to average fruit weight of eight pomegranate cultivars under studying, data indicated non-significant differences among cultivars (‘Dholka’, ‘Kandhari’, ‘Bedana’, ‘Chawla’, ‘Mridula’, ‘G-137’, and ‘Jyoti’) but significant difference from ‘Kashmir Local’. The highest fruit weight was recorded in ‘Dholka’ (252.17 g) followed by ‘Kandhari’ (245.61 g), ‘Bedana’ (242.08) as compared to ‘Kashmir Local’ (130.40 g). Similar results were also reported by Lal *et al.*, (2002). The variation in fruit weight was because of genetic behavior of varieties. The fruit volume also shown same trend as fruit weight and ranged between 49.16 ml and 79.64 ml. The maximum volume was recorded in ‘Dholka’ followed by ‘Kandhari’ and ‘Bedana’. Thus, it is revealed that there is a close relation between fruit weight and fruit volume. Fruit firmness index was found non-significant among all the varieties and its value ranged from 27.70 to 49.16. The cultivars ‘Chawla’, ‘Kandhari’ and ‘Kashmir Local’ varieties seed found harder than ‘Mridula’, ‘Dholka’, ‘Jyoti’, ‘Bedana’ and ‘G-137’. Color of aril also differed according to cultivars. In ‘Chawla’ and ‘Mridula’ aril was red color while ‘Dholka’, ‘Bedana’, ‘Kandhari’, ‘Jyoti’, ‘G-137’, ‘Kashmir Local’ it was pink to pinkish red.

The highest mean fruit yield/plant was recorded in ‘Dholka’ (6.54 kg) followed by ‘Bedana’ (6.06 kg), ‘Kandhari’ (5.48 kg) as compared to ‘Kashmir Local’ (3.26 kg). Fruit physical characteristics like rind weight differed significantly among cultivars. The maximum rind weight recorded in ‘G-137’ followed by ‘Kandhari’ and ‘Local Kashmiri’. Rind thickness was also varies among all the cultivars from 1.27 mm to 4.46 mm. These values were little higher than values reported by Sarkhosh *et al.* (2006). Number of Seed + Aril was recorded maximum in ‘Jyoti’ (639.133) followed by ‘G-137’ (631.33) and ‘Bedana’ (616.33), while weight of Seed

Table 2 : Physical properties of fruit, yield, cracking, disease and insect incidence parameters of the eight pomegranate cultivars

Varieties	Yield/plant (k.g.)	Rind weight (gm)	Rind thickness (mm)	No. of seed+Aril/fruit	Wt. of seed+Aril/fruit (gm)	Seed residue in juice (gm)	Juice %	Fruit Cracking (%)	Anar butterfly incidence (%)	Aphid incidence (%)
Chawla	6.087	90.033	2.400	500.067	180.033	21.133	65.100	34.547	14.067	17.300
Mridula	3.533	91.033	3.000	459.067	177.133	18.067	60.100	33.863	16.033	15.300
Jyoti	5.227	99.327	4.400	639.133	210.537	23.067	70.100	33.763	12.257	20.267
G-137	6.180	146.333	4.467	631.333	158.053	22.927	80.667	38.620	18.787	14.300
Dholka	8.547	103.540	4.400	487.667	169.527	27.333	74.667	41.843	16.123	10.300
Bedana	8.062	120.200	4.200	616.333	175.533	24.667	76.667	37.667	15.273	13.267
Kandhari	7.480	128.613	4.133	567.333	184.653	38.713	71.333	45.667	19.253	16.300
Local Kashmiri	5.260	126.333	1.27	498.667	144.747	31.607	64.000	49.113	32.123	23.300
CD at 5%	0.273	0.272	0.249	71.917	7.173	1.152	4.124	0.010	0.073	0.047
CV	2.449	0.136	3.977	7.396	2.318	2.639	3.128	0.015	0.229	0.164

Table 3 : Fruit quality and storage characteristics of the eight pomegranate genotypes grown under Kerawa condition of Kashmir

Varieties	TSS (° Brix)	Titriable Acidity (%)	Reducing Sugar (%)	Ascorbic Acid (mg/100gm)	Total Sugar (%)	Maturity index (TSS/TA)	Juice pH	Chlorophyll content (%)	Storage at ambient condition (days)
Chawla	13.133	0.454	6.037	10.413	8.487	29.163	4.033	26.667	45.500
Mridula	14.067	0.356	6.120	10.227	8.237	39.473	4.333	36.667	50.467
Jyoti	14.527	0.441	6.117	12.247	8.707	32.937	3.853	62.767	52.567
G-137	13.953	0.480	6.140	11.533	8.443	29.043	4.033	41.567	48.567
Dholka	14.560	0.532	6.340	12.753	8.417	27.347	4.233	72.567	63.567
Becana	13.833	0.664	7.127	11.527	9.823	20.840	3.860	12.833	59.533
Kandhari	14.147	0.524	7.507	12.507	9.973	26.973	4.040	28.200	56.500
Local Kashmiri	13.660	0.440	6.140	10.007	9.443	31.073	4.467	42.667	65.267
CD at 5%	0.060	0.010	0.053	0.064	0.005	0.823	0.096	8.292	0.306
CV	0.244	1.177	0.463	0.317	0.035	1.572	1.321	11.582	0.313

+ Aril of fruit ranged from 144.74 g to 210.53 g in selected cultivars. The juice percentage was significantly higher in 'G-137', 'Bedana', 'Dholka' and 'Kandhari' as compared to 'Kashmir Local'. Siddappa (1943) also reported that cultivars differ in their juice content due to different genetic constitution. The seed residue in juice varied from 18.06 g to 38.71 g. Fruit cracking was recorded minimum (33.76 %) in 'Jyoti' and maximum (49.11 %) in 'Kashmir Local'. That may be due to less rind thickness of 'Kashmir Local' and also may be due to sudden changes in climate at the time of maturity as well as variation in soil moisture and tolerance of cultivars to cracking. This is accordance with the findings of Banker and Prasad (1992).

The TSS in juice of different varieties varied from 13.13 °Brix in 'Chawla' to 14.56 °Brix in 'Dholka'. However, inter-varietal differences were statically significant (Table 3). This results were lower than values observed (16–19 °Brix) by Poyrazoglu et al., (2002), while present results were in agreement with values (10–16.5 °Brix) reported by Fadavi *et al.*, 2005 and Shulman *et al.*, (1984). The titrable acidity (as citric acid) ranged from 0.356 % in 'Mridula' to 0.532% in 'Dholka'. The inter-varietal differences were highly significant. The prevalence of wide range in acid content in juice of different cultivars is probably the reason to use this character to classify pomegranate cultivars as sweet, sour or bitter sweet (Cains, 1940 and Cheema *et al.*, 1949). Cultivar Kandhari produced the highest content of ascorbic acid in fruits (12.75 and 12.50 mg ascorbic acid / 100 ml juice), respectively as compared to 'Kashmir Local' (10.00 mg ascorbic acid / 100 ml juice). Similar results were also reported by Kulkarni and Aradhya (2005) in cultivar Ganesh. The content of reducing sugar and total sugar differ significantly among the cultivars and maximum reducing sugar recorded in 'Kandhari' 7.50 %, 'Bedana' 7.12% and 'Dholka' 6.34 % as compared to 'Kashmir Local' 6.14%. However, total sugar ranged from 8.23 % in 'Mridula' to 9.97 % in 'Kandhari'. The maturity index (TSS/TA) is responsible for the taste and flavor of pomegranate, which some author used for classifying the pomegranate cultivars (Martinez et al., 2006; Cam et al., 2009b).

This classification has been optimized for Spanish cultivars: maturity index (MI) = 5–7 for sour, MI = 17–24 for sour–sweet and MI = 31–98 for sweet cultivars (Martinez *et al.*, 2006). In the similar fashion the maturity index values varied from 20.84–39.47. The cultivar Mridula had the highest MI (Table 3). In previous studies variable ranges of maturity index (Viswanath *et al.*, 1999; Martinez *et al.*, 2006; Cam *et al.*, 2009a; Sarkhosh *et al.*, 2006) were reported.

The content of juice pH ranged among cultivars from 3.85 in ‘Jyoti’ to 4.46 in ‘Kashmir Local’ (Table 3). The pH values obtained in the current study are greater than those reported by Cam *et al.* (2009a) on pomegranate cultivars grown in Turkey. According to the results, cultivar type plays an important role in terms of their total soluble solids, pH, titrable acidity, total sugars and maturity index of the pomegranate juice. All the cultivars investigated were suitable for direct consumption and production of pomegranate juice because they had the high levels of soluble solids. Total chlorophyll content of leaves was also varied among cultivars and the maximum chlorophyll content was recorded in ‘Dholka’ (72.56 %) followed by ‘Jyoti’ (62.76 %) and ‘Kashmir Local’ (42.66 %). Shelf life also differ according to cultivars and the maximum storage life under ambient condition (16–26 °C) recorded in ‘Kashmir Local’ (65.26 days) followed by ‘Dholka’ (63.56 days) and ‘Bedana’ (59.53 days). These variations in vegetative growth, physico-chemical characteristics of fruits and yield were mainly due to genotypic variation of the varieties Mahajan and Dhillon, (2000), though agro-climatic conditions could not be overlooked (Mali & Prasad 1999). Anar butterfly incidence was ranged between 12.25–32.12 %, and the maximum incidence in ‘Kashmir Local’ and lowest ‘Jyoti’ similarly aphid attack recorded maximum in ‘Kashmir Local’ (23.30%) and minimum in ‘Dholka’ (10.30 %). The results revealed that ‘Kashmir Local’ is more susceptible to anar butterfly and aphid attack and ‘Jyoti’ and ‘Dholka’ are less susceptible.

CONCLUSION

The performance of eight pomegranate

cultivars for vegetative growth, morphology, yield and quality attributes of fruits were evaluated for their suitability to Karewa condition of Kashmir Valley. Out the eight cultivars evaluated ‘Bedana’, ‘Chawla’ and ‘Jyoti’ were found more vigorous than others. Cultivar Dholka showed its superiority with respect to fruit set, fruit size, fruit weight, number of fruits, fruit calyx diameter and length, yield/tree, TSS, ascorbic acid, titrable acidity and minimum aphid attack while ‘Kandhari’ was superior in reducing sugar, and total sugar. However, ‘Jyoti’ was better in duration of flowering, number of Seed + Aril, minimum fruit cracking, juice pH, anar butterfly attack compared to other cultivars.

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