



Performance of pomegranate (*Punica granatum*) genotypes in rainfed temperate region

A K SHUKLA^{1*}, K K PRAMANICK¹, S WATPADE¹, M PATIAL¹ and J KUMAR²

ICAR-Indian Agricultural Research Institute, Regional Station, Amartara Cottage, Shimla,
Himachal Pradesh 171 004, India

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ABSTRACT

An experiment was conducted at the ICAR-Indian Agricultural Research Institute, Regional Station, Shimla to evaluate the performance of pomegranate genotypes in rainfed temperate region during 2014–17. For this purpose performance of 13 pomegranate genotypes, viz. Kandhari Yellow, Anar Sherin Mohmad Ali, G-137, Chawla, P-75-K-5, Ichakdana, Ganesh, Kandhari Hansi, Jodhpur Red, Kandhari Kabuli, P-23, P-26, Nabha were assessed for plant growth, yield and quality parameters. The study reveals that plant height varied from 1.85-2.83 m, canopy spread (east-west side) was highest in Nabha (2.10 m) and canopy spread in north-south side varied from 1.05-1.85 m with maximum in P-26 (1.85 m). Plant girth was maximum in Kandhari Yellow (68.65 mm) and minimum in Ichakdana (34.71 mm). Fruit set in different genotypes of pomegranate varied from 29.87-78.25% with maximum in Ichakdana (78.25%). The maximum fruit weight was recorded in Ichakdana (320.4 g) and lowest in P-23 (118.6 g). Maximum fruit length and fruit width was recorded in Ichakdana (87.8 mm and 88.25 mm). Aril weight was highest in Ichakdana (171.32 g) and minimum in P-75-K-5 (48.0 g). Fruit yield varied from 12.18-30.11 (t/ha) with maximum in Kandhari Kabuli (30.11 t/ha) and minimum in P-75K-5 (12.18 t/ha). TSS content varied from 9.18-14.02% with maximum in Kandhari Kabuli (14.02%) and minimum in Ichakdana (9.18%). Acidity content was found maximum in Ichakdana (2.38%) and minimum in Ganesh (0.98%). Vitamin C content varied from 8.44-14.13 mg/100 g with maximum in Ichakdana (14.13 mg/100 g) and minimum in Kandhari Yellow (8.44 mg/100 g). Total sugar content varied from 5.21-11.33% with maximum in Kandhari Yellow (11.33%) and minimum in Ichakdana (5.12%).

Keywords: Genotypes, Pomegranate, Plant Growth, Quality Parameters, Rainfed, Temperate Region, Yield

Pomegranate (*Punica granatum* L.) belongs to the family Punicaceae is native to Iran (Persia) and is one of the oldest fruits known to mankind. It has been traditionally cultivated since ancient times under diverse agro-climatic conditions. Pomegranate fruits are important for human health because of their high antioxidant, polyphenols and anthocyanins content (Gil *et al.* 2000). The acceptability of pomegranate to the consumer and processor depends on aggregate of certain quality attributes that are related to the physico-chemical properties inclusive of size, skin colour, sugar content, acidity and flavour (Al-Said *et al.* 2009). The pomegranate fruit is non-climacteric in nature and the timing of harvest is an important aspect to be considered for fresh market or for storage. Pomegranate

is a favourite fruit of tropical, subtropical and arid regions (Pareek 1981). In India, it commercially grown in about 1.3 lakh hectare and production 13.45 lakh tonnes with average productivity of 10.3 tonne/ha (NHB 2014). Major pomegranate growing areas in India are Maharashtra, Karnataka, Andhra Pradesh, Gujarat, Tamil Nadu and Rajasthan. It grows wild in Western Himalayan regions that include Union Territories like Himachal Pradesh, Jammu and Kashmir and Uttarakhand (Pandey *et al.* 2008). Some wild types pomegranate (locally known as *Daru*) also found in mid and foot hills of Himachal Pradesh which can be exploited for *anardana* purpose (Singh and Singh 2006). It is deciduous in temperate ecosystem and an evergreen or partially deciduous in tropical and subtropical conditions. These beneficial effects may be related to its high antioxidant activity resulting from the presence of a variety of biologically active compounds (Aviram 2002, Halvorsen *et al.* 2002). The edible part of the fruit contains considerable amount of acids, sugar, vitamins, polysaccharides, polyphenols and minerals (Kulkarni *et al.* 2004). Traditionally, pome and stone fruits were the major fruit crops of temperate ecosystem. In spite of various pomegranate cultivars grown in different regions of India,

¹ICAR-Indian Agricultural Research Institute, Regional Station, Amartara Cottage, Shimla, Himachal Pradesh; ²ICAR-National Institute of Biotic Stresses Management, Raipur, Chhattisgarh. *Corresponding author email: akshuklahort@gmail.com

as such there is no recommended cultivar specially for mid to high hilly regions based performance evaluation. With the changing scenario of climatic conditions pomegranate may become an alternative fruit crop for temperate region.

MATERIALS AND METHODS

The study was carried out at the Horticultural Research Farm, Dhanda under ICAR-Indian Agricultural Research Institute, Regional Station, Shimla, Himachal Pradesh. The experimental plants of 13 genotypes, viz. Kandhari Yellow, Anar Sherin Mohamad Ali, G-137, Chawla, P-75-K-5, Ichakdana, Ganesh, Kandhari Hansi, Jodhpur Red, Kandhari Kabuli, P-23, P-26, Nabha with uniform age were selected. The uniform management practices with respect to nutrition and other cultural practices were adopted for all the genotypes. Pomegranate genotypes (rooted cuttings) were transplanted in the field at 3 m × 3 m apart under square system of planting. Plant growth parameters, viz. plant height, girth, canopy spread; yield attributing traits like fruit size, fruit weight, number of fruits/plant, yield/plant; and quality parameters, viz. aril weight, acidity, TSS, total sugar, reducing sugar, non-reducing sugar, vitamin-C etc. were recorded from 2014 to 2017 and presented based on pool data. At the time of fruit harvest five fruits from each plant were collected randomly for physico-chemical analysis. Size of fruit was recorded with the help of vernier calliper. TSS was determined with the help of hand refractometer. Titrable acidity was estimated by titrating the known volume of juice with 0.1 N NaOH, using phenolphthalein as an indicator. Total sugar, reducing sugar, non-reducing sugar and vitamin-C were analysed as per A.O.A.C (1998). The soil of experimental site was sandy loam with gravel having low fertility status and poor water holding capacity. Meteorological parameters like temperature, rainfall and relative humidity were also recorded during fruiting period for interpretation of experimental results. Single tree of each genotype constituted an experimental unit and each genotype was replicated four times. The data analysed following RBD for meaningful interpretation.

RESULTS AND DISCUSSION

Plant Growth, Dormancy, flowering and fruit set: Data (Table 1) on vegetative growth attributes of pomegranate elucidates that plant height varied from 1.85-2.83 m with maximum in Jodhpur Red (2.83 m) and minimum in P-75-K-5 (1.85 m). Variation in plant height may be due to growth behaviour of individual plant/genotype however, edapho-climatic factors also play an important role in plant vigour. Canopy spread (east-west side) was found maximum in Nabha (2.10 m) followed by Jodhpur Red (2.05 m), P-26 (2.0 m), Kandhari Kabuli (1.70 m) and minimum in Ganesh (1.10 m). Canopy spread (north-south side) varied from 1.05-1.85 m with maximum in P-26 (1.85 m) and minimum in P-75K-5 (1.05 m). Mir *et al.* (2010a) also found high range of variability for plant height and canopy spread. Plant girth was maximum in Kandhari yellow (68.65 mm) followed by G-137 (62.35 mm), Anar Sherin Mohamad Ali

(56.32 mm), Kandhari Hansi (55.07mm) and minimum reported in Ichakdana (34.71 mm). Rao and Subramaniam (2009) were recorded findings in almost similar pattern. Sinha *et al.* (2018) also reported variations in vegetative parameters in exotic pomegranates genotypes.

Dormancy period in different pomegranate genotypes varied from 55-128 days with maximum in Anar Sherin Mohamd Ali (128 days) and minimum in G-137 (55 days) and in rest of the genotypes period in between was recorded. In pomegranate flowering is dependent on existing weather conditions of particular locality however, time taken in completion of flowering (from first flower initiation to 100% flowering) varied from 11-27 days with maximum in Ganesh (27 days) followed by Jodhpur Red (26 days), Nabha and P-23 (21 days), and minimum in Kandhari Hansi (11 days). Time taken from flowering to fruit set varied from 15-29 in different genotypes of pomegranate. Flowering and fruit set is genetic phenomenon of individual genotype but it is also influenced by existing climatic condition of a particular location. Fruit set in different genotypes of pomegranate varied from 29.87-78.25% with maximum in Ichakdana (78.25%) and minimum in P-75-K-5 (29.87%) rest were in between these two genotypes. Shukla *et al.* (2016) also studied flowering and fruit set in different genotypes of pomegranate. Fruit drop in pomegranate is prevalent during May-June particularly when there is continuous soil moisture stress in temperate ecosystem. Maximum fruit drop was recorded in Ichakdana (36.65%) followed by Kandhari Yellow (30.11%), P-75-K-5 (29.83%), Chawla (28.65%) and minimum in Jodhpur Red (10.18%). Number of fruit/cluster varied from 1-2 to 2-4 in different genotypes with highest in Kandhari Hansi (2-4 fruits/cluster).

Fruit Characters: Data on fruit weight (Table 1) elucidates that maximum fruit weight was recorded in Ichakdana (320.4 g) followed by Kandhari Kabuli (313.2 g), P-26 (284.2 g), Kandhari Hansi (281.5 g) and minimum was recorded in P-23 (118.6 g). Kumar and Khosla (2009) studied the physical characteristics of different pomegranate cultivars and significant variation was recorded. Weight of 10 aril was found varying from 18.11-29.12 g with maximum in Ichakdana (29.12 g) and minimum in P-75-K-5 (18.11 g) rest were in between these two genotypes. Juice recovery was maximum in Kandhari Hansi (59.36%) followed by Kandhari Kabuli (58.68%), Jodhpur Red (57.11%), Nabha (55.66%) and minimum was recorded in Kandhari Yellow (41.30%). Days taken from full bloom to fruit maturity varied from 125-155 days with maximum in Anar Sherin Mohamd Ali (155 days) and minimum in Ichakdana (125 days) and rest cultivars were in between these two. Fruit cracking a serious problem in pomegranate particularly in arid and semi-arid region however, it is relatively less serious in temperate region and it may be due to existing edapho-climatic factors of the region. Maximum cracked fruit was recorded in P-75-K-5 (22.6%) closely followed by Anar Sherin Mohamd Ali (21.7%), Kandhari Yellow (20.17%) and P-23 (20.12%) however, minimum was found in Ichakdana (10.1%). Fully developed pomegranates cracks

Table 1 Evaluation of pomegranate germplasm for growth, flowering and fruit characters

Germplasm	Plant height (m)	Canopy spread (m)		Plant girth (mm)	Dormancy period (days)	Time taken in completion of flowering (days)	Days taken from flowering to fruit set	Fruit set (%)	Fruit drop (%)	No. of fruit/ cluster	Fruit weight (g)	Weight of ten arils (g)	Juice recovery/ 100 g aril (%)	Days from full bloom to maturity	Fruit cracking (%)	Fruit length (mm)	Fruit Width (mm)	Aril weight (g)	Aril content (%)
		EW	NS																
Ichakdana	2.06	1.3	1.25	34.71	85	14	15	78.25	36.65	2-4	320.4	29.12	49.62	125	10.1	84.3	88.35	171.32	53.47
Ganesh	1.95	1.1	1.20	42.38	114	27	29	59.98	15.81	1-2	219.0	26.78	55.25	142	15.2	70.14	70.02	140.0	63.92
Kandhari Hansi	2.57	1.45	1.50	55.07	123	11	15	54.89	15.92	2-3	281.5	27.4	59.36	137	12.3	81.3	85.48	163.65	58.13
Kandhari Kabuli	2.65	1.70	1.55	50.63	115	13	17	57.12	14.76	1-3	313.2	28.93	58.68	132	13.2	83.89	86.95	166.0	53.01
Jodhpur Red	2.83	2.05	1.80	48.03	120	26	24	45.88	10.18	1-2	227.25	26.97	57.11	140	15.3	72.08	72.44	115.25	50.71
P-23	2.01	1.55	1.45	50.08	72	21	21	49.52	18.45	1-2	118.6	21.80	51.23	143	20.12	60.97	62.85	77.0	54.92
P-26	2.18	2.0	1.85	42.36	97	20	29	53.45	15.88	2-3	284.2	18.23	50.82	146	18.6	84.42	82.89	168.4	59.25
Nabha	2.82	2.1	1.79	44.65	119	21	20	38.19	13.58	1-2	277.4	21.21	55.66	153	14.50	82.28	78.85	146.6	52.91
Anar Sherin Mohamd Ali	2.23	1.45	1.25	56.32	128	14	23	30.85	18.45	2-3	186.8	20.21	52.92	155	21.7	70.64	72.29	138.92	54.36
10 G-137	2.10	1.25	1.35	62.35	55	19	26	46.11	20.46	2-3	203.4	19.91	50.75	148	13.75	73.03	75.29	139.0	68.41
11 Chawla	2.81	1.35	1.25	49.23	120	15	20	40.23	28.65	1-2	177.4	18.46	45.61	139	17.6	69.32	68.63	77.8	43.95
12 P-75 K-5	1.85	1.25	1.05	46.63	67	14	19	29.87	29.83	2-3	120.8	18.11	43.69	148	22.6	54.32	57.64	48.0	39.74
13 Kandhari Yellow	2.63	1.50	1.40	68.65	107	20	16	30.82	30.11	1-3	178.3	19.05	41.30	146	20.17	76.93	80.75	129.82	52.80
CD (P=0.05)	0.12	0.09	0.10	2.56	4.33	1.12	1.21	5.95	3.62	---	2.22	0.14	0.12	0.98	0.19	0.99	1.02	1.98	0.46

Table 2 Evaluation of pomegranate genotypes for yield and quality characters

Germplasm	Peel weight (g)	Peel content (%)	Peel thickness (mm)	No. of aril/ fruit	No. of seed/ fruit	Seed content (%)	Time of harvesting	No of fruits/ plant	Fruit yield (t/ha)	Dry matter content (%)		TSS (%)	Acidity (%)	Vitamin-C content (mg/100g)	No-reducing sugar (%)	Reducing sugar (%)	Total sugar (%)
										Aril	Peel						
Ichakdana	149.08	46.53	7.62	705	455	64.53	29 Aug-02 Sept.	32	23.77	27.2	42.34	9.18	2.38	14.13	1.19	4.02	5.21
Ganesh	79.00	36.08	2.59	694	288	41.49	13-16 Sept.	43	22.12	22.32	31.65	13.6	0.98	12.11	2.33	7.55	9.88
Kandhari Hansi	117.85	41.87	2.68	608	402	66.11	12-17 Sept.	55	28.32	23.12	33.59	13.4	1.13	13.85	1.85	8.38	10.23
Kandhari Kabuli	147.2	46.99	6.94	596	425	71.31	14-18 Sept.	62	30.11	24.09	32.68	14.02	1.24	14.12	2.64	8.12	10.76
Jodhpur Red	112.0	49.29	4.76	492	298	60.57	30 Aug-05 Sept.	40	18.44	20.17	29.98	13.37	1.35	8.77	2.41	7.15	9.56
P-23	41.6	35.08	3.65	373	209	56.03	15-20 Sept.	32	15.61	19.12	28.12	12.3	1.12	11.89	2.32	6.55	8.87
P-26	115.8	40.75	4.50	268	198	73.88	14-19 Sept.	38	22.92	18.62	28.33	13.32	1.23	10.85	1.99	6.13	8.12
Nabha	130.6	47.09	5.90	306	201	65.68	18-22 Sept.	25	20.09	17.53	30.15	13.56	1.13	9.45	1.80	7.85	9.65
Anar Sherin Mohamd Ali	48.8	25.64	3.55	298	211	70.80	17-20 Sept.	31	19.26	16.12	28.78	12.88	0.99	9.87	1.86	5.99	7.85
G-137	64.2	31.59	3.01	329	225	68.38	12-17 Sept.	28	18.25	18.66	31.40	12.96	1.22	10.23	2.29	7.69	9.98
Chawla	99.2	56.05	5.65	501	355	70.85	19-23 Sept.	25	14.99	20.56	32.67	11.5	1.15	11.21	1.89	8.23	10.12
P-75 K-5	72.8	60.26	3.38	258	219	84.88	21-25 Sept.	22	12.18	21.93	37.1	12.5	1.18	9.78	2.02	7.12	9.14
Kandhari Yellow	48.8	27.2	4.56	311	258	82.95	22-26 Sept.	29	17.25	16.66	32.10	12.85	1.20	8.44	2.77	8.56	11.33
CD (P=0.05)	0.38	0.17	0.11	1.11	0.55	0.47	---	0.14	1.22	0.23	0.15	0.10	NS	0.11	0.09	0.085	0.08

due to moisture imbalances, as they are very sensitive to variation in soil moisture and, day and night atmospheric moisture deficit. Prolonged drought causes hardening of the peel. If this is followed by irrigation or rains, the pulp grows and ultimately the peel cracks. Kumar *et al.* (2018) observed that air temperature rise was found to be the cause of fruit cracking. Cracking of pomegranate fruit is mainly governed by edapho-climatic condition of particular area however, role of micronutrient and genotypic characters is also responsible for fruit cracking. Significant variations were reported in fruit cracking among different cultivars by Singh (2004). Mir *et al.* (2007) reported among different cultivars under study, cultivar Chawla exhibited less cracking incidence (6.32%) followed by Kandhari. However, Maximum cracking was observed in cultivar G-137 (31.40%) followed by Ganesh (26.30%). Data (Table 1) shows that maximum fruit length was recorded in Ichakdana (87.8 mm) and minimum was found in P-75-K-5 (54.32 mm). Fruit width was maximum in Ichakdana (88.25 mm) followed by Khadhari Kabuli (86.95 mm), Kandhari Hansi (85.48 mm), P-26 (82.89 mm) whereas minimum was recorded in P-75-K-5 (57.64 mm). Fruit size is generally controlled by genetic makeup of particular genotype but integrated orchard management may also have major role in improving fruit size of pomegranate. Shukla *et al.* (2016) studied the physical characteristics of different pomegranate cultivars. Data (Table 1) elucidates that maximum aril weight was exhibited in Ichakdana (171.32 g) followed by P-26 (168.4 g), Kandhari Kabuli (166.0 g), Kandhari Hansi (163.65 g) whereas minimum was found in P-75-K-5 (48.0 g). Aril content in different pomegranate genotypes varied from 39.74-68.41% with maximum in G-137 (68.41%) and minimum in P-75-K-5 (39.74%). Varasteh *et al.* (2012) also reported variation in different physical parameters in pomegranate variety Rabbab-e-Neyriz. Maximum rind weight was recorded in Ichakdana (149.08 g) followed by Kandhari Kabuli (147.2 g) Nabha (130.6 g), Kandhari Hansi (117.85 g). Peel content varied from 25.64-60.26% with maximum in P-75-K-5 (60.26%). Maximum rind thickness was recorded in Ichakdana (7.62 mm) followed by Kandhari Kabuli (6.94 mm) Nabha (5.90 mm), Chawla (5.65 mm) whereas minimum was found in Ganesh (2.59 mm). Number of aril per fruit was found to be maximum in Ichakdana (705) followed by Ganesh (694), Kandhari Hansi (608), Kandhari Kabuli (596) however, minimum was found in P-75-K-5 (258). Variations were also observed in fruit characteristics including aril content by Akbarpour *et al.* (2009), Varasteh *et al.* (2009). Maximum number of seed per fruit varied from 198-455 with maximum in Ichakdana (455) minimum in P-26 (198). Per cent seed content in arils of different pomegranate genotypes varied from 41.49-84.88% with maximum in P-75-K-5 (84.88%) and minimum in Ganesh (41.49%), seed content in aril of rest genotypes was in between these two. Mir *et al.* (2007) observed high range of variability in pomegranate for fruit weight, fruit volume, number of seeds, fruit colour and general appearance among the cultivars under study.

Fruit yield and quality parameters: Fruit harvesting of pomegranate genotypes varied from 29th August to 26th September however, there was early harvesting in Ichakdana in between 29th August to 02nd September and Kandhari Yellow was harvested late from 22-26 September. All other genotypes were harvested in between. Number of fruit/plant was maximum in Kandhari Kabuli (62) followed by Kandhari Hansi (55), Ganesh (43), Jodhpur Red (40) however minimum was recorded in P-75-K-5 (22). Fruit yield (tonne/ha) varied from 12.18-30.11 t/ha with maximum in Kandhari Kabuli (30.11 t/ha) followed by Kandhari Hansi (28.32 t/ha), Ichakdana (23.77 t/ha) P-26 (22.92 t/ha), and minimum in P-75K-5 (12.18 t/ha). Kumar and Khosla (2009) also reported variation in yield and yield attributing traits. Dry matter content (Table 2) in aril varied from 16.12-27.2% with maximum in Ichakdana (27.2%) and minimum with Anar Sher-in Mohamd Ali (16.12%). However, dry matter content in peel was maximum in Ichakdana (42.34%) followed by P-75-K-5 (37.1%), Kandhari Hansi (33.59%), Kandhari Kabuli (32.68%) whereas, minimum was recorded in P-23 (28.12%). TSS content varied from 9.18-14.02% with maximum in Kandhari Kabuli (14.02%) and minimum in Ichakdana (9.18%) and rest all cultivars were in between these two genotypes. Differences in various quality parameters in different genotypes were also reported by Viyar *et al.* (2017). Acidity content was found to be the maximum in Ichakdana (2.38%) followed by Jodhpur Red (1.35%), Kandhari Kabuli (1.24%), P-26 (1.23) and minimum was recorded in Ganesh (0.98%). Vitamin C content varied from 8.44-14.13 mg/100 g with maximum in Ichakdana (14.13 mg/100 g) followed by Kandhari Kabuli (14.12 mg/100 g), Kandhari Hansi (13.85 mg/100), Ganesh (12.11 mg/100 g) and minimum in Kandhari Yellow (8.44 mg/100 g). Non-reducing sugar content was maximum in Kandhari Yellow (2.77%) followed by Kandhari Kabuli (2.64%), Ganesh (2.33%), whereas, minimum was observed in Ichakdana (1.19%). Wani *et al.* (2012) also found variation in his findings while screening pomegranate varieties. The maximum reducing sugar was observed in Kandhari Yellow (8.56%) followed by Kandhari Hansi (8.38%), Chawla (8.23%), Kandhari Kabuli (8.12%) however minimum was found in Ichakdana (4.02%). Total sugar content varied from 5.12-11.33% with maximum in Kandhari Yellow (11.33%) and minimum in Ichakdana (5.12%) and rest all genotypes were in between these two. Prasad *et al.* (2012), Prasad and Bankar (2000) also reported similar finding in pomegranate with respect to variations in physico-chemical attributes.

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