

## Performance of pomegranate cultivars under semi-arid climatic conditions

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### ABSTRACT

Pomegranate (*Punica granatum L.*) is a popular fruit crop of arid and semiarid regions of the world with immense therapeutic and nutritional value. An experiment was conducted at the Rani Lakshmi Bai Central Agricultural University, Jhansi to evaluate the performance of eight pomegranate cultivars under semi-arid climate during 2020–22. The cultivars were Bhagwa, Super Bhagwa, Ganesh, G-137, Ruby, Mridula, Arkata and Jalore Seedless. The results showed that Jalore Seedless had the tallest plant, G-137 had the widest canopy (east-west) and Ruby had the widest canopy (north-south). The flowering period varied from last week of February to 3<sup>rd</sup> week of April among different cultivars. The fruit maturity period ranged from 145 days to 170 days. Bhagwa had the highest percentage of hermaphrodite flowers and Jalore Seedless and Ganesh had the highest percentage of male flowers. Ganesh had the highest pollen viability percentage and Jalore Seedless had the lowest. Super Bhagwa had the highest yield (15.7 kg), number of fruits per plant (61.0) and fruit weight (258.4g). Ganesh, G-137, Ruby, Mridula and Arkata had round fruits, Bhagwa, Super Bhagwa and Jalore Seedless had ovate fruits. Bhagwa, Super Bhagwa, Ruby, Mridula and Arkata had red fruit skin. Bhagwa and Super Bhagwa had red arils, Mridula and Arkata had dark red arils. Bhagwa, Super bhagwa G-137, Ruby and Mridula had low fruit drop. Bhagwa, Super Bhagwa, Ruby, Mridula, Arkata, Jalore Seedless had low fruit cracking. Among the cultivars tested, Bhagwa, Ruby, Mridula and Arkata showed low fruit borer attack. Super Bhagwa and Ganesh had the highest TSS content (14.3<sup>o</sup>Brix), while G-137 had the lowest acidity content (0.43%). Ganesh also had the highest TSS/acid ratio and total sugar content, but Bhagwa had the highest vitamin C content. Super Bhagwa was the best cultivar for marketable yield, fruit quality and pest tolerance under semi-arid conditions of Bundelkhand region.

**Keywords:** Cultivars, flowering, pomegranate, yield and quality

### INTRODUCTION

Pomegranate (*Punica granatum L.*) is an ancient and valuable fruit crop that belongs to the Punicaceae family. It can grow in various agro-climatic regions, especially in arid and semi-arid areas, where it produces high-quality fruits with hardy and adaptable characteristics (Teixeira da Silva *et al.*, 2013; Marathe *et al.*, 2017). The fruit is popular for its juicy, sweet arils that have a refreshing taste. The fruit has a high demand for fresh consumption and processing into various products, such as juice, syrup, squash, wine and anardana, a souring agent. Pomegranate is also a functional food that has many health benefits, as it contains several phytochemicals that can prevent diseases (Kanoun *et al.*, 2020; Parashar, 2010; Melgarejo and Salazar, 2003).

India is one of the world's largest pomegranate producers and has a year-round production cycle with a peak season from February to May. The main pomegranate growing states in India are Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu and Rajasthan. Maharashtra alone accounts for more than 70% of the total area under pomegranate and produces 17.48 lakh MT of pomegranate annually (NHB, 2022). The country has seen a rise in the area and production of pomegranate due to the identification and development of suitable cultivars and standardization of their agro-techniques. Pomegranate can adapt to a wide range of climates from tropical to temperate regions, and it shows a lot of variability depending on genetical, soil type, environmental factors. In this study, we collected

promising pomegranate genotypes, grew them under semi-arid region of Jhansi and evaluated their performance to determine the best cultivars for local climatic conditions.

## **MATERIALS AND METHODS**

Eight promising cultivars were collected from National Research Centre on Pomegranate, Solapur, Maharashtra in September, 2017. The hard wood rooted cutting planting materials of cvs 'Arkata', 'Bhagwa', 'Super Bhagwa', 'Ganesh', 'G-137', 'Jalore Seedless', 'Mridula' and 'Ruby' planted at 3 x 4 m spacing during 2017-18 at Fruit Research Station, Rani Lakshmi Bai Central Agricultural University, Jhansi. Geographically the farm is situated at latitude 25°30' N, longitude 78°32' E and at an elevation of 258 meters above main sea level. It has semi-arid climate with average annual rainfall of 800 to 900 mm and temperature ranging between 3.0°C to 47.8°C. These climatic conditions are considered ideal for the cultivation of high-quality pomegranates.

The experiment was carried out for two consecutive years during ambe bahar i.e., flowering period of March-April in the years of 2021 and 2022 at fruit research station, RLBCAU, Jhansi. The experiment was conducted in randomized block design with five replications. The plants were given uniform cultural operations.

The observations recorded were plant height, plant spread, tree growth habit, foliage density, floral biology, fruit set to maturity period, yield and quality attributes characters. The plant height was measured from ground the ground level to the apex of the crown, using a marking stick and average height of the replication was expressed in cm. Spread of the plant from two sides, i.e., east-west and north-south was observed with the help of a linear scale and expressed in cm. The growth habit was observed and recorded as per its visual appearance and expressed as spreading, semi-spreading and erect type based on plant height to spread ratio. Foliage density was observed in running per meter and interpreted as sparse, medium and dense. The plant growth parameters were recorded, as recommended in the descriptor of NBPGR (Mahajan *et al.*, 2002) and guidelines for DUS testing of PPV and FRA. Simultaneously, differences for appearance of flower bud to full

bloom period and fruit set to maturity were noted and expressed as flowering and fruit set to maturity duration in terms of days. The percentage of hermaphrodite/male flowers was computed by dividing total number of hermaphrodite/male flowers blossomed within the tagged flowers by total numbers of flower. The sex ratio of flowers was computed by dividing the number of hermaphrodite flowers by the number of male flowers. The yield was recorded at the time of harvest and expressed in terms of kg per plant. The total soluble solids were determined with the help of a hand refractometer and reading corrected at room temperature. For biochemical analysis of the fruits, the methods were followed as described by A.O.A.C (1990). The data were analyzed statistically and test of significance were done by following the statistical method RBD as described by Panse and Sukhatme (1985)

## **RESULTS AND DISCUSSION**

### **Plant growth parameters**

Table 1 shows the plant growth parameters of eight pomegranate cultivars. These parameters include plant height, spread, growth habit and foliage density. The plant height among the selected cultivars exhibited significant variations and the maximum plant height was recorded in 'Jalore Seedless' (230.0 cm) followed by Ruby (222.6 cm), G-137 (221.8 cm), whereas 'Arkata' gave the minimum plant height (178.4 cm). The plant height varied from 2.13 m to 2.63 m among eight pomegranate cultivars grown in Jammu climate, which is consistent with the findings of Bhat *et al.* (2019). The genetic makeup of the plant may influence these variations in plant height. However, the variations in the plant height of same varieties in the different area may be due to adaptability and performance of varieties with the prevailing local soil and climate condition.

The highest plant spread on east-west direction was recorded for G-137 (201.8 cm), whereas, Arkata exhibited the lowest east-west spread (103.8 cm). Ruby gave the highest north-south spread (201.0 cm) and Arkata exhibited the lowest north-south spread (101.2 cm). Similar type of variation in plant height and plant spread has been reported in pomegranate (Sharma and Bist, 2005; Meena *et al.*, 2011; Bhat *et al.*, 2019). Out of eight genotypes,

**Table 1: Plant growth parameters of eight cultivars of pomegranate**

Treatments	Tree height (cm)	Tree spread (cm)		Tree growth habit	Tree foliage density
		E-W	N-S		
Bhagwa	213.0	172.4	198.2	Spreading	Medium
Super Bhagwa	212.4	170.0	155.8	Spreading	Medium
Ganesh	204.2	176.4	174.6	Spreading	Medium
G-137	221.8	201.8	181.4	Spreading	Medium
Ruby	222.6	191.6	201.0	Spreading	Dense
Mridula	201.0	162.0	170.0	Spreading	Dense
Arkata	178.4	103.8	101.2	Compact	Dense
Jalore Seedless	230.0	195.2	176.2	Upright	Medium
CD at 5%	15.17	15.58	14.65	-	-

**Table 2: Duration of flower and fruit set to maturity of eight cultivars of Pomegranate.**

Treatments	Date of start of flowering	Date of end of flowering	Duration from fruit set to maturity
Bhagwa	2 <sup>nd</sup> week of March	3 <sup>rd</sup> week of April	170.0
Super Bhagwa	2 <sup>nd</sup> week of March	3 <sup>rd</sup> week of April	169.0
Ganesh	3 <sup>rd</sup> week of March	1 <sup>st</sup> week of April	162.0
G-137	3 <sup>rd</sup> week of March	1 <sup>st</sup> week of April	153.0
Ruby	1 <sup>st</sup> week of March	3 <sup>rd</sup> week of April	164.0
Mridula	Last week of February	2 <sup>nd</sup> week of April	145.0
Arkata	Last week of February	2 <sup>nd</sup> week of April	154.0
Jalore Seedless	1 <sup>st</sup> week of March	2 <sup>nd</sup> week of April	164.0
CD at 5%	-	-	8.94

**Table 3: Yield attributes characters of eight pomegranate cultivars**

Treatments	Fruit yield per plant (kg)	No. of the fruits per plant	Fruit weight (g)	Fruit shape	Fruit skin colour	Aril colour
Bhagwa	10.6	43.0	247.0	Ovate	Red	Red
Super Bhagwa	15.7	61.0	258.4	Ovate	Red	Red
Ganesh	10.6	45.0	235.8	Round	Yellowish	Pink
G-137	12.2	51.8	236.8	Round	Yellowish	Pink
Ruby	12.7	55.2	231.2	Round	Red	Pink
Mridula	7.9	39.8	200.4	Round	Red	Dark Red
Arkata	8.9	45.2	197.0	Round	Red	Dark Red
Jalore Seedless	6.4	25.6	252.8	Ovate	Yellowish	White
CD at 5%	3.7	16.32	21.52	-	-	-

Bhagwa, Super Bhagwa, Ganesh, G-137, Ruby, Mridula showed spreading tree growth habit. Most pomegranate varieties exhibited a spreading growth habit, except for Arkata and Jalore Seedless, which had a compact and upright habit. These results are

consistent with those of Sharma and Bist (2005), who reported that the cultivars Ganesh, Mridula and G-137 showed a spreading growth habit. The tree foliage density i.e., dense foliage density was showed in Ruby, Mridula and Arkata whereas,

**Table 4: Physiological disorder, insect and pest incidence of eight cultivars of pomegranate**

Treatments	Fruit Drop (kg/plant)	Fruit cracking (kg/plant)	Sun scald	Fruit borer	Fruit sucking moths	Bacterial blight	Wilt
Bhagwa	1.45	1.32	Low	Low	Nil	Nil	Nil
Super Bhagwa	1.49	1.17	Low	Medium	Nil	Nil	Nil
Ganesh	2.24	2.27	Low	Medium	Nil	Nil	Nil
G-137	1.66	2.29	Low	Medium	Nil	Nil	Nil
Ruby	1.62	1.70	Low	Low	Nil	Nil	Nil
Mridula	1.40	1.45	Low	Low	Nil	Nil	Nil
Arkata	1.53	1.20	Low	Low	Nil	Nil	Nil
Jalore Seedless	2.86	1.74	No	Medium	Nil	Nil	Nil
CD at 5%	0.54	0.63	-	-	-	-	-

**Table 5: Fruit quality parameters of eight cultivars of pomegranate**

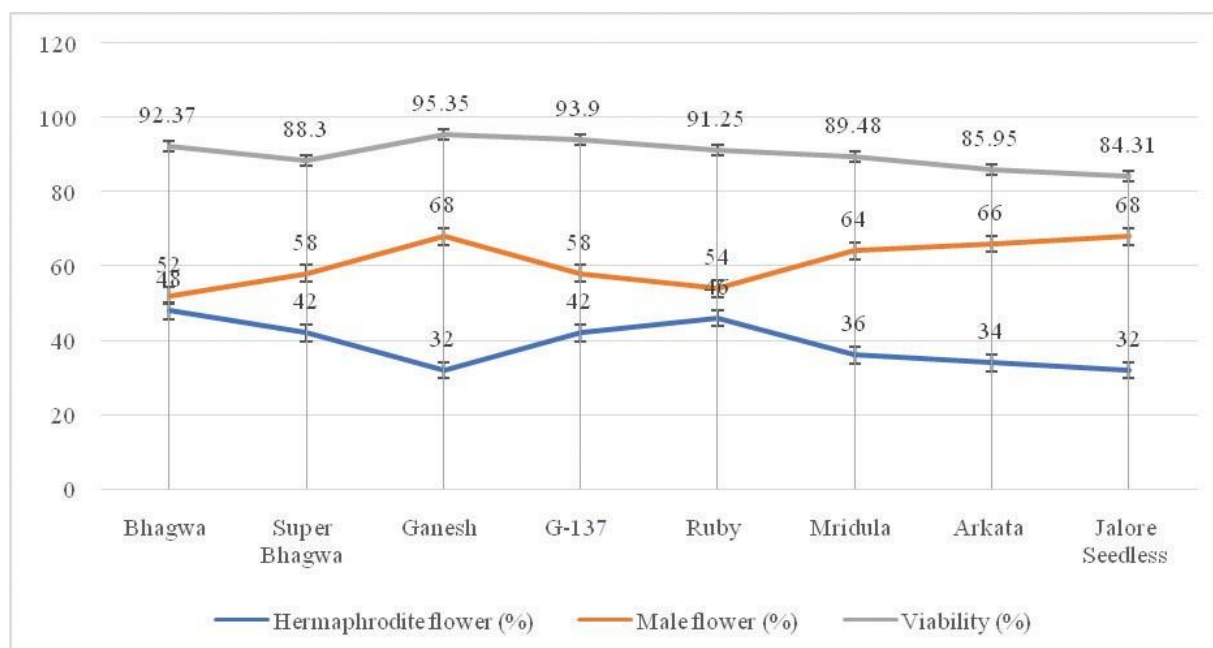
Treatments	TSS ( <sup>o</sup> Brix)	Acidity (%)	TSS/Acid ratio	Total sugar (%)	Vitamin-C (mg/100g of aril)
Bhagwa	12.4	0.53	23.3	8.92	11.64
Super Bhagwa	14.3	0.48	29.7	9.00	10.82
Ganesh	14.3	0.47	30.4	9.03	10.57
G-137	12.1	0.43	28.1	8.70	11.02
Ruby	12.7	0.52	24.4	8.45	10.00
Mridula	12.4	0.44	28.1	8.64	10.34
Arkata	11.6	0.56	20.7	8.33	10.56
Jalore Seedless	13.2	0.60	22.0	8.54	10.11
CD at 5%	0.75	0.05	3.24	0.26	0.20

cultivar Bhagwa, Super Bhagwa, Ganesh, G-137 and Jalore Seedless showed medium foliage density.

**Time and duration of flowering, flower type, pollen viability, maturity of fruits**

Under climatic conditions at Jhansi, the pomegranate was observed to flower throughout the year. However, with the objective of obtaining higher fruit productivity, minimizing the loss due to vagaries of climate and ensuring confident demand in the market for the produce (with dark aril colour, higher production with less incidence of insect and pest), its flowering is conventionally regulated in three distinct seasons viz., flowering during February-March (ambe bahar), flowering during July-August (mrigbahar) and flowering during September-October (hasht bahar). The data presented table 2 reveals that in Jhansi climatic condition, date of start of flowering varied among

different cultivars and was recorded between last week of February to 3<sup>rd</sup> week of March. Earliest cultivar to start first flowering was Mridula and Arkata (last week of February) whereas last cultivar to open its first flowering was Ganesh and G-137 (3<sup>rd</sup> week of March). The earliest cultivar to open its last flower was Ganesh and G-137 (1<sup>st</sup> week of April), whereas Bhagwa, Super Bhagwa and Ruby took more days to open its last flower on 3<sup>rd</sup> week of April. Duration from fruit set to maturity ranged from shortest 145 days to longest 170 days. The minimum duration from fruit set to fruit maturity was taken by the cultivar Mridula, whereas, Bhagwa took maximum duration from fruit set to maturity. The result is more or less in close conformity with the findings of Babu *et al.* (2017). The variation in maturity period of different pomegranate cultivars might be due to the genetic background and environmental conditions.



**Fig. 1: Hermaphrodite and male flower, pollen viability percentage of eight cultivars of Pomegranate**

### Type of flowers and pollen viability of pomegranate flowers

The examination of data presented in Fig. 1 reveals that the cultivar Bhagwa had the highest percentage of hermaphrodite flower (48 %), followed by Ruby (46 %), Super Bhagwa and G-137 (42.00 %) while in lowest Jalore Seedless and Ganesh (32 %). Whereas, cultivar Jalore Seedless and Ganesh (68 %) recorded highest percentage of male flower followed by Arkata (66 %), Mridula (64 %), while lowest in Bhagwa (52 %). The pollen viability of pomegranate flowers is an important phenomenon governing the fruit set to fruit harvesting. The pollen viability percentage ranged from 95.35 per cent being highest in cultivar Ganesh to lowest of 84.31 per cent in Jalore Seedless. Different dissimilarity was also reported by Babu *et al.* (2011). Pollen viability of most of the fruit crops is mostly genetic trait, as same variety under varied climatic conditions consistently recorded higher percentages of pollen viability. Different testing procedures and also time of bahar as well as time of collection of pollen done by different personnel may account for very minor discrepancies in pomegranate pollen viability.

### Fruit yield and physical characteristics of fruit

Table 3 shows the fruit yield attributes, which depends on the number of fruits per plant, the fruit weight and other physical factors. Fruit yield showed significant variation among the eight cultivars evaluated. The highest yield was recorded in Super Bhagwa (15.7 kg/plant), followed by Ruby (12.7 kg/plant) and G-137 (12.2 kg/plant), whereas the lowest was recorded in Jalore Seedless (6.4 kg/plant). Similarly, the highest number of fruits per plant was recorded in Super Bhagwa (61.0) while, lowest number of fruits was found in Jalore Seedless (25.6). The highest fruit weight was recorded in Super Bhagwa (258.4 g), followed by Jalore Seedless (252.8 g), Bhagwa (247.0 g) and lowest fruit weight was found in Arkata (197.0 g). These findings are in close agreement with the results of Prasad *et al.* (2013). The variations in the yield attributes parameters in different cultivars might be due to genetic background, environmental condition and agronomical practices. The majority of pomegranate cultivars such as Ganesh, G-137, Ruby, Mridula and Arkata had round type of fruit shape, Bhagwa, Super Bhagwa and Jalore Seedless ovate type of fruit shape. The cultivar Bhagwa, Super Bhagwa, Ruby, Mridula and Arkata had red colour of fruit skin during time of harvesting,



Ganesh, G-137 and Jalore Seedless had yellowish fruit colour. The aril colour of Bhagwa and Super Bhagwa had red, Ganesh, G-137 and Ruby had pink, Mridula and Arkata had dark red, Jalore Seedless had white in colour. The peels and arils of pomegranate contain various types of flavonoids, anthocyanins, and tannins, which give them their distinctive colour and antioxidant properties (Zhao *et al.*, 2022). Ghosh *et al.* (2012) found that colour of aril was changed with time of maturity. It was pink when the fruits were harvested during May and became light red in June and red in July. Ranpise *et al.* (2014) found that in pomegranate arils anthocyanin content was generally lower in fruit harvested during June-July and higher in the fruit harvested during November-December. The decrease in anthocyanin content was possibly due to degradation of anthocyanins by high sunlight intensity observed during May-June.

#### **Incidence of physiological disorder, insects and pests**

Incidence of major physiological disorder, pest and disease determine the economic feasibility of a cultivar in the region. It was cleared from data presented in the table 4, showed that Jalore Seedless had highest incidence of fruit drop, medium incidence in Ganesh and Arkata, while lowest was in Bhagwa, Super Bhagwa, G-137, Ruby and Mridula. Majority of cultivars are also low with respect to incidence of fruit cracking observed during fruit growth and development period. The cultivars Bhagwa, Super Bhagwa, Ruby, Mridula, Arkata, Jalore Seedless recorded low incidence of fruit cracking, while Ganesh and G-137 recorded medium incidence of fruit cracking. The results obtained in this aspect was in conformity with the findings of Yuan *et al.* (2010), who also observed fruit cracking percentage to vary from 1.5 % to 45.9%. Different cultivars showed different susceptibility to fruit borer, the cultivar Bhagwa, Ruby, Mridula and Arkata recorded low incidence of fruit borer attack, while medium attack recorded in Super Bhagwa, Ganesh, G-137. All the cultivars were free from fruit sucking moths, bacterial blight and wilt during the period of investigation.

#### **Quality characteristics of fruits**

Based on the results on fruit quality parameters among the cultivars under investigation, it may be

inferred from the study that the different cultivars showed a wide range of variability with respect to fruit quality attributes. Thus, an effective selection can be made based on quality characters for future improvement through a breeding programme. The data on fruit quality parameters (Table 5) showed that the highest total soluble solids content was found in cultivars Super Bhagwa and Ganesh (14.3 °Brix), followed by Jalore Seedless (13.2 °Brix), Ruby (12.7 °Brix), Bhagwa (12.4 °Brix) and Mridula (12.4 °Brix), while lowest in Arkata (11.6 °Brix). The studies are in confirmation with the early works made by Kumar *et al.* (2020) who had revealed that the Ganesh had maximum total soluble solids (14.71 °Brix) whereas, Patil *et al.* (2013) also found similar results and stated that the total soluble solids of Ganesh was higher than that of Arkata. The variations in total soluble solids content might be due to the occurrence of rainfall during fruit maturity which might have increased the moisture content of the fruit and dilution of carbohydrates. The acidity per cent was highest in Jalore Seedless (0.60 %), whereas, it was lower in G-137 (0.43 %) and Mridula (0.44 %). This type of variation has also been reported by Wani *et al.*, (2012). The variation of acidity might be due to different ripening stages and due to prevailing climatic conditions *i.e.* low temperature, lesser sunshine and high humidity. The TSS/acid ratio was highest in cultivar Ganesh (30.4), followed by Super Bhagwa (29.7), G-137 (28.1) and Mridula (28.1), while the lowest in Arkata (20.7). The total sugar content range between 8.33 in Arkata to 9.03 % in Ganesh. According to Bhat *et al.* (2019), the total sugar content of local Selection and G-137 varieties was 8.45% and 9.02%, respectively, under the sub-tropical conditions of Jammu. The highest vitamin-C content of 11.64 mg/100ml was recorded in cultivar Bhagwa which was statistically above all the cultivars. The minimum vitamin-C content was recorded as 10.0 mg/100ml in Ruby.

#### **CONCLUSION**

From the above findings, it is concluded that Super Bhagwa can be recommended for commercial cultivation under semi-arid climatic condition in Jhansi district of Uttar Pradesh as it gave highest yield and also good quality fruit. Another cultivar that is suitable for cultivation is

Ruby, which has the second highest yield among the tested cultivars and produces fruits of good quality. From quality point of view, the cultivar Ganesh was found superior to others owing to its highest TSS: acid ratio.

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