



## Induction of flowering and improvement of fruit yield and quality in pomegranate (*Punica granatum*) cv. Bhagwa by various plant growth regulators

Hussain F.<sup>1</sup>✉, Murthy, B.N.S.<sup>2</sup>, Reddy, M.L.N.<sup>3</sup>, Satisha, J.<sup>1</sup>, Upreti, K.K.<sup>4</sup>, Laxman, R.H.<sup>4</sup>, Srinivasulu, B.<sup>3</sup>

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### Abstract

The effect of different plant growth regulators on flowering, fruiting, yield, and quality of pomegranate (*Punica granatum* L.) cv. Bhagwa was studied in a field trial at ICAR - Indian Institute of Horticultural Research (IIHR), Bengaluru, during two seasons, namely *ambe bahar* (January–February) 2016 and *hashta bahar* (September–October) 2016-17. Nitrobenzene (NB) 1.0, 1.5, and 2.0 ml plant<sup>-1</sup>, Cycocel (CCC) 500, 1000, and 1500 ppm plant<sup>-1</sup>, Uracil 25 and 50 ppm plant<sup>-1</sup>, CCC 1000 ppm + Uracil 25 ppm plant<sup>-1</sup>, CCC 1500 ppm + Uracil 50 ppm plant<sup>-1</sup>, and Control were among the eleven treatments studied. The application of uracil 50 ppm plant<sup>-1</sup> resulted in a higher number of hermaphrodite flowers plant<sup>-1</sup> (264.7), number of fruits plant<sup>-1</sup> (154.0), and fruit yield (27.1 kg/plant). Fruit weight (197.6 g), fruit length (6.64 cm), total aril weight (113.63 g), 100 aril weight (27.18 g), fruit juice weight (101.94 g), TSS content (19.96 °B), fruit anthocyanin content (6.46 mg 100 g) and low titrable acidity (0.41 percent) were recorded when CCC 1000 ppm + Uracil 25 ppm plant<sup>-1</sup> was applied. During *ambe bahar*, the highest fruit width (6.90 cm) and volume (162.7 ml) were observed with CCC 1000 ppm and 1500 ppm plant<sup>-1</sup>, respectively. During *hashta bahar*, CCC 1500 ppm plant<sup>-1</sup> resulted in a higher number of hermaphrodite flowers (287.8), the highest percentage of fruit set (86.10), the highest number of fruits plant<sup>-1</sup> (156.66), the highest fruit yield (54.53 kg plant<sup>-1</sup>), the highest fruit weight (348.32 g), the longest fruit length (8.53 cm), and the largest fruit volume (8.53 cm) (33.93 ml), total aril weight (224.01 g), 100 aril weight (35.09 g), fruit juice weight (119.40 g) and TSS content (16.00 °B). A foliar spray of nitrobenzene 1.5 ml plant<sup>-1</sup> compounded the high fruit anthocyanin content (6.47 mg 100g<sup>-1</sup>). As a result of the research, it can be concluded that CCC 1000 ppm + Uracil 25 ppm plant<sup>-1</sup> and CCC 1500 ppm plant<sup>-1</sup> were the most effective treatments for improving floral characters, fruiting, yield, and quality in pomegranate cv. Bhagwa during both seasons.

**Key words:** *Bhagwa, Plant growth Regulators, Pomegranate, Flowering, Yield*

### Introduction

Pomegranate (*Punica granatum* L.) is a nutritious and medicinal hardy fruit crop that can be grown in both tropical and subtropical climates (Aziz and Miah, 2009). The plant is native to Iran, and it was first cultivated there around 2000 B.C. (Supe and Saitwal, 2016). Pomegranate cultivation has grown in popularity over the years due to its adaptability to a wide range of agro-climatic conditions, inherent ability to withstand drought, salinity,

### Author's Address

<sup>1</sup>Division of Fruit Crops, ICAR – Indian Institute of Horticultural Research, Bengaluru, India

<sup>2</sup>Mission for Integrated Development of Horticulture, Ministry of Agriculture and Farmers Welfare, New Delhi, India

<sup>3</sup>Dr YSR Horticultural University, Venkataramannagudem, Andhra Pradesh – 534 101, India

<sup>4</sup>Division of Plant Physiology and Biochemistry, ICAR – Indian Institute of Horticultural Research, Bengaluru, India

E-mail: [fkhanshaik@gmail.com](mailto:fkhanshaik@gmail.com)

alkalinity, and high temperature stresses, and commercial profitability (high returns with low input costs), secondary metabolites such as anthocyanins, such as delphinidin, cyanidin, and pelargonidin, and polyphenols, such as ellagic acid and punicalgins, known for their potent antioxidant activities; and profound medicinal and therapeutic value due to the presence of numerous secondary metabolites such as anthocyanins, such as delphinidin, cyanidin, and pelargonidin, and secondary metabolites such as (Pal *et al.*, 2014). India is the world's largest pomegranate producer, with 2.86 million tonnes of fruit produced from 0.24 million hectares of land (National Horticulture Board, 2018). Because of its attractive red skin, deep red arils, soft seeds (mellowness), and export demand, cv. 'Bhagwa' is the most common pomegranate cultivar among the many available



(Dhinesh *et al.*, 2017). Although the fruit grows exclusively from hermaphrodite flowers, the pomegranate produces three types of flowers: male (bell shaped), hermaphrodite (vase shaped), and intermediate (tubular) (Prasad *et al.*, 2012). If fruit set occurs in such flowers, the fruits can drop off before reaching maturity, even if they become misshaped (Arvind *et al.*, 2018). The percentage of hermaphrodite flowers is proportional to the plant's bearing ability and determines the degree of fruit set (Chaudhari and Desai, 1993). According to studies, cultivars with a high ratio of hermaphrodite to male flowers have a high fruit yield potential, so encouraging the growth of hermaphrodite flowers is an obvious way to increase pomegranate yields (Wetzstein *et al.*, 2015). The male flower's ovary is rudimentary, while the intermediate flower's ovary is degenerating. The ovary of the bisexual flowers is well formed and has a large base. Male flowers drop and do not set, so bisexual flowers are the only ones that produce fruit (Yahya *et al.*, 2017). The climate influences pomegranate flowering, and the plant has three distinct flowering seasons in India (January–February, locally known as *ambebahar*, June–July, locally known as *mrig bahar*, and September–October, locally known as *hastha bahar* (Kumar *et al.*, 2008). The availability of irrigation water, the occurrence and extent of disease and pest damage, and consumer demand all influence the choice of a particular season, or 'bahar,' at a given location (Hoda and Hoda 2013). In temperate and subtropical climates, pomegranate grows as a deciduous shrub, but in India's tropical climate, the plant prefers to remain evergreen and flowers almost all year. As a result of this plant growth pattern, the yield is low and the fruits are of varying sizes (Aziz *et al.*, 2012). Regulating pomegranate flowering in tropical conditions to obtain higher proportions of hermaphrodite flowers would be useful for obtaining higher yields and economic returns (Aseri *et al.*, 2008). Plant growth regulators (PGRs) are said to influence physiological processes and endogenous hormone levels in horticultural crops, resulting in quantitative and qualitative improvements (Phawa *et al.*, 2017). Durgude *et al.*, (2019) found that foliar spray of cycocel 2000 ppm enhanced the number of hermaphrodite flowers in pomegranate cv. Phule Bhagwa. Sangeetha *et al.*, (2014) exonerated that

application of 0.5 % nitrobenzene as foliar spray has increased flowering and yield in Moringa. Application of paclobutrazol @ 1.25 g a.i. per metre canopy diameter induced early flowering in mango cv. Totapuri (Upreti *et al.*, 2012). Many experiments on the use of PGRs in a variety of crops have been attempted. They are considered to play an important role in pomegranate flower sex change (Singh *et al.*, 2016). Auxins, gibberellins, and other growth regulators influence the growth, flowering, yield, and quality of a variety of crops (Aziz *et al.*, 2013). Despite their well-known influence on other fruit crops (Anawal *et al.*, 2015), the effect of PGRs, specifically nitrobenzene, cycocel, and uracil, on flowering, fruit yield, and fruit quality in pomegranate has yet to be investigated—a gap that the current study seeks to fill. In terms of chemical costs, nitrobenzene is the least expensive, followed by cycocel and uracil (Kohombange *et al.*, 2017). There are no studies indicating that nitrobenzene, cycocel, or uracil have a negative impact on human health.

### Materials and Methods

The trial was carried out at the ICAR – IIHR, Hesaraghatta, Bengaluru on safe and uniformly grown tissue - cultured plants of pomegranate cv. Bhagwa obtained from M/s Jain Irrigation Pvt. Ltd, Jalgoan (Maharashtra) during *ambe bahar* (January – February) and *hastha bahar* (September - October) seasons of 2016-17. During the experiment, the average maximum and minimum temperatures were 33.08°C and 20.43°C, respectively with relative humidity and rainfall of 75.04 % and 74.95 mm. All the plants were initially stressed by withholding irrigation for a month and defoliation was achieved by foliar application of ethrel @ 2 ml litre (prior to imposition of treatments) followed by twig pruning. The spacing adopted was 4.5 × 5.0 m. The experiment consisted of eleven treatments that were replicated thrice with a randomized block design. The treatments were: T<sub>1</sub> – nitrobenzene 1.0 ml / litre, T<sub>2</sub> – nitrobenzene 1.5 ml / litre, T<sub>3</sub> – nitrobenzene 2.0 ml / litre, T<sub>4</sub> – cycocel 500 ppm, T<sub>5</sub> - cycocel 1000 ppm, T<sub>6</sub> – cycocel 1500 ppm, T<sub>7</sub> – uracil 25 ppm, T<sub>8</sub> – uracil 50 ppm, T<sub>9</sub> – cycocel 1000 ppm + uracil 25 ppm, T<sub>10</sub> – cycocel 1500 ppm + uracil 50 ppm and T<sub>11</sub> – control (water spray). Before and during the study,

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standard cultural procedures such as desuckering were carried out.

The following observations were recorded: number of flowers of different types, fruit size and yield, and fruit quality parameters. The numbers of male, hermaphrodite, and intermediate flowers were counted from one quarter of the plant canopy of each selected plant and the number per plant was arrived at by multiplying the numbers with four. Fruit set was determined by counting the number of lemon-sized fruits present on the entire plant. Weight of individual fruits was the average weight in grams of nine randomly selected fruits from each treatment. The percentage fruit set was calculated as follows:

$$\frac{\text{Number of fruits harvested}}{\text{number of hermaphrodite flowers}} \times 100$$

At harvest, the number of fruits from all the treatments was counted and the mean value expressed as the number of fruits per tree. Fruit yield was recorded by recording the weight of fruits harvested at maturity and expressed in kilograms per tree. The length of a fruit was measured from the stalk end to the stylar end using a digital vernier calliper and expressed in centimetres. The maximum width of a fruit was also measured similarly. The volume of nine randomly selected fruits was measured by the water displacement method. Total aril weight was calculated by separating the arils from the randomly selected fruits and weighing them individually, and the mean aril weight was expressed in grams per fruit. The weight of 100 arils was recorded by extracting 100 arils from each of the nine randomly selected fruits from each treatment and the mean value was expressed in grams. Total soluble solids (TSS) were quantified using a hand-held refractometer (Carl Zeiss, Make: Nr 322577, Germany), and the mean value was expressed in °Brix. Acidity of the juice was estimated by titration (AOAC, 2000). Anthocyanin content of arils was determined by the method described by Srivastava and Kumar (2003): anthocyanin was extracted by putting the samples (10 g each) along with 10 mL of ethanolic HCl in a blender, transferring the homogenized suspension to 100 mL volumetric flasks, making up the volume with ethanolic HCl, storing the mix in a refrigerator at 4 °C, and then filtering through a Whatman No.1

filter paper. The absorbance of the filtrate was recorded at 520 nm.

$$\text{Anthocyanin (mg 100g}^{-1}\text{)} = \frac{\text{O.D.}_{520} \times \text{volume made up}}{\text{weight of sample}} \times 100$$

The data were analysed using the analysis of variance (ANOVA; Gomez and Gomez, 1984).

## Results and Discussion

### Effect on flowering

Data on the effect of various PGRs on flowering are given in Table 1. During Ambe bahar, uracil 50 ppm led to the maximum number of hermaphrodite flowers (264.7); During hastha bahar, it was Cycocel 1500 ppm that achieved a similar result (287.84). The effect of uracil can be attributed to the increase in RNA content (Ramteke and Somkumar, 2005): uracil is a component of RNA, which plays a role in protein synthesis and gene expression and, in turn, in phytohormone production (Sivaningappa *et al.*, 2017). It is evident that exposure of plants to stress in pomegranate promoted accumulation of proline which acted as an endogenous signal to induce flowering (Neale, 1990). Further, a positive correlation was observed between leaf proline content and the number of hermaphrodite flowers produced (Powerwanto and Inoue, 1990). Application of ethrel at high concentration (2 ml / litre) to defoliate pomegranate also regulates flowering (Saroj *et al.*, 2017). Foliar application of ethrel causes activated gene expression of cell-wall degrading enzymes such as cellulase and polygalacturonase. Ethrel perception was found involved in the arrest of stamen development through induction of DNA damage which promotes hermaphrodite flower production in some plant species (Xie *et al.*, 2015). The effect of Cycocel can be attributed to lower levels of endogenous gibberellins, which inhibit the conversion of geranylgeranyl pyrophosphate to entkaurene in the gibberellin synthesis pathway (Jain and Dashora, 2007). Reduced gibberellin inhibits cell elongation, reducing annual vegetative growth and promoting reproductive growth, as evidenced by the increased number of hermaphrodite flowers. Hezagi and Stino (1985) found a higher proportion of hermaphrodite flowers in olive with application of cycocel.

**Table 1: Induction of flowering in pomegranate as influenced by different plant growth regulators**

Treatment	<i>Ambe bahar</i> (Jan.–Feb. 2016)			<i>Hastha bahar</i> (Sept.–Oct. 2016)		
	Number of male flowers	Number of hermaphrodite flowers	Number of intermediate flowers	Number of male flowers	Number of hermaphrodite flowers	Number of intermediate flowers
T <sub>1</sub> , nitrobenzene 1.0 mL / plant	264.66	215.66	179.66	277.40	195.05	215.43
T <sub>2</sub> , nitrobenzene 1.5 mL / plant	274.00	206.66	201.83	283.42	203.66	231.23
T <sub>3</sub> , nitrobenzene 2.0 mL / plant	268.66	211.66	198.66	252.27	241.02	234.57
T <sub>4</sub> , (Cycocel) 500 ppm	288.33	193.33	197.16	243.79	256.69	238.52
T <sub>5</sub> , (Cycocel) 1000 ppm	277.83	196.66	195.66	232.63	261.19	245.02
T <sub>6</sub> , (Cycocel) 1500 ppm	258.00	190.66	196.66	219.70	287.84	250.53
T <sub>7</sub> , uracil 25 ppm	258.00	259.66	195.66	252.13	220.73	230.50
T <sub>8</sub> , uracil 50 ppm	241.00	264.66	194.33	241.69	222.66	236.40
T <sub>9</sub> , T <sub>5</sub> + T <sub>7</sub>	275.33	201.33	207.83	234.75	239.99	250.08
T <sub>10</sub> , T <sub>6</sub> + T <sub>8</sub>	287.66	196.00	226.66	234.99	243.43	254.14
T <sub>11</sub> , Control	312.33	188.66	190.00	286.14	181.85	204.06
C.D. at 5%	N.S.	44.10	N.S.	14.68	11.51	11.22
S. Em (±)	16.74	14.84	12.27	4.94	3.87	3.77

\* N.S. – Non Significant

**Effect on yield and its attributes**

The percentage of fruit set in the ambe bahar was unaffected by any of the treatments (Table 2), while uracil 50 ppm increased the number of fruits to 154 and the fruit yield to 27.1 kg per plant. Cycocel 1500 ppm increased fruit set (86.1%), number of fruits per plant (156.7), and maximum yield (54.5 kg per plant) in the hastha bahar, outperforming all of the other nine treatments. The increased number of hermaphrodite flowers and delayed abscission (the effect of cytokinins and auxins) achieved by retaining the pectin content in the middle lamella (Kachave and Bhosale, 2007), effect on sex expression (Chaudhari and Desai, 1993), and better pollen tube growth leading to reduced flower drop could all contribute to Cycocel's improved fruit

collection. Increased amounts of metabolites are required for fruit growth as a result of restricted vegetative growth. Similar findings were made in mango (Daulta *et al.*, 1981) and guava (Daulta *et al.*, 1981). (Saravanan and Kanowjia, 2008). The increased number of hermaphrodite flowers resulted in increased fruit set and retention, as well as an increase in the number of fruits per plant. These findings are similar to those of Desai *et al.* (1982) in 'Kagzi' lime and Guha (1993) in apple. Cycocel, a growth retardant, is said to change the source–sink relationship in plants by redeploying carbohydrates directly or indirectly to suppress vegetative growth and encourage reproductive growth, resulting in increased yield. Furthermore,

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Cycocel and uracil influence auxin metabolism, (1972) reported similar results in mango, and which may have resulted in increased fruit number Shawky *et al.*, (1998) and Shikhamany and Reddy and size, resulting in increased yield. Maiti *et al.*, (1989) reported similar results in grapes.

**Table 2: Fruit yield and its attributes in pomegranate as influenced by different plant growth regulators**

Treatment	<i>Ambe bahar (Jan.–Feb. 2016)</i>			<i>Hastha bahar (Sept.–Oct. 2016)</i>		
	Fruit set (%)	Number of Fruits/plant	Fruit Yield (kg/plant)	Fruit set (%)	Number of Fruits/plant	Fruit yield (kg/tree)
T <sub>1</sub> , nitrobenzene 1.0 mL / plant	66.30	139.16	24.73	37.52	96.33	26.66
T <sub>2</sub> , nitrobenzene 1.5 mL / plant	55.76	113.83	21.50	40.63	106.00	29.68
T <sub>3</sub> , nitrobenzene 2.0 mL / plant	62.77	132.00	24.18	48.01	115.66	32.52
T <sub>4</sub> , (Cycocel) 500 ppm	51.67	99.66	19.61	70.01	142.66	45.12
T <sub>5</sub> , (Cycocel) 1000 ppm	54.22	105.00	20.36	75.50	147.33	47.93
T <sub>6</sub> , (Cycocel) 1500 ppm	52.01	99.16	18.70	86.10	156.66	54.53
T <sub>7</sub> , uracil 25 ppm	59.09	153.00	26.98	39.26	94.33	28.38
T <sub>8</sub> , uracil 50 ppm	58.16	154.00	27.10	40.36	98.33	29.90
T <sub>9</sub> , T5 + T7	55.55	107.00	20.98	46.72	104.00	29.21
T <sub>10</sub> , T6 + T8	56.08	106.00	19.84	51.02	112.66	32.80
T <sub>11</sub> , Control	52.05	98.33	16.31	31.49	90.66	24.52
C.D. at 5%	N.S.	31.90	6.39	4.18	12.42	5.78
S.Em (±)	7.00	10.73	2.15	1.41	4.18	1.94

\* N.S. – Non Significant

**Table 3: Fruit size in pomegranate as influenced by different plant growth regulators**

Treatment	<i>Ambe bahar (Jan.–Feb. 2016)</i>				<i>Hastha bahar (Sept.–Oct. 2016)</i>			
	Weight (g)	Length (cm)	Fruit Width (cm)	Volume (mL)	Weight (g)	Length (cm)	Width (cm)	Volume (mL)
T <sub>1</sub> , nitrobenzene 1.0 mL / plant	177.80	6.34	6.49	136.58	276.61	7.65	7.83	267.37
T <sub>2</sub> , nitrobenzene 1.5 mL / plant	187.07	6.47	6.74	125.53	280.13	7.82	7.98	276.86
T <sub>3</sub> , nitrobenzene 2.0 mL / plant	183.00	6.18	6.38	143.26	281.24	7.86	8.06	267.17
T <sub>4</sub> , (Cycocel) 500 ppm	196.31	6.57	6.83	160.08	315.86	8.33	8.28	300.60
T <sub>5</sub> , (Cycocel) 1000 ppm	193.66	6.57	6.84	162.70	325.05	8.49	8.36	310.60
T <sub>6</sub> , (Cycocel) 1500 ppm	187.25	6.50	6.90	155.62	348.32	8.53	8.96	333.93
T <sub>7</sub> , uracil 25 ppm	176.82	6.40	6.67	126.43	299.93	8.04	8.12	263.80
T <sub>8</sub> , uracil 50 ppm	176.88	6.37	6.75	125.37	303.91	8.11	7.96	287.06
T <sub>9</sub> , T5 + T7	197.55	6.64	6.82	160.54	280.82	8.34	8.06	239.41
T <sub>10</sub> , T6 + T8	187.43	6.62	6.59	150.60	290.75	8.00	8.14	203.87
T <sub>11</sub> , Control	166.54	6.03	6.20	135.05	270.41	7.71	7.66	263.74
C.D. at 5%	15.66	0.39	0.30	27.81	23.62	0.58	N.S.	37.53
S.Em (±)	5.27	0.13	0.10	9.36	7.95	0.19	0.35	12.63

\* N.S. – Non Significant

**Table 4: Fruit quality parameters in pomegranate as influenced by different plant growth regulators**

Treatment	<i>Ambe bahar (Jan.–Feb. 2016)</i>						<i>Hastha bahar (Sept.–Oct. 2016)</i>					
	Total aril weight (g)	100-aril weight (g)	Juice weight (g)	TSS (°B)	Titration acidity (%)	Anthocyanin (mg 100 g <sup>-1</sup> )	Total aril weight (g)	100 Aril weight (g)	Juice weight (g)	TSS (°B)	Titration acidity (%)	Anthocyanin (mg 100 g <sup>-1</sup> )
T <sub>1</sub> , nitrobenzene 1.0 mL / plant	95.73	24.92	56.91	18.50	0.54	5.07	149.21	32.15	92.01	15.76	0.63	5.08
T <sub>2</sub> , nitrobenzene 1.5 mL / plant	103.94	24.42	89.93	16.39	0.68	5.14	160.01	28.96	93.90	15.94	0.57	6.47
T <sub>3</sub> , nitrobenzene 2.0 mL / plant	97.30	24.65	62.01	18.25	0.52	5.27	159.72	31.02	96.70	15.44	0.52	5.27
T <sub>4</sub> , (Cycocel) 500 ppm	110.80	26.97	92.31	19.12	0.48	5.60	191.98	32.25	112.38	15.15	0.58	5.61
T <sub>5</sub> , (Cycocel) 1000 ppm	105.00	26.58	86.66	19.44	0.43	5.80	199.98	34.24	115.87	14.45	0.68	5.81
T <sub>6</sub> , (Cycocel) 1500 ppm	104.84	25.87	72.37	19.96	0.41	5.11	224.01	35.09	119.40	16.00	0.54	5.11
T <sub>7</sub> , uracil 25 ppm	96.26	23.86	60.73	15.82	0.66	4.66	177.77	31.89	95.57	14.70	0.64	4.66
T <sub>8</sub> , uracil 50 ppm	98.55	24.74	51.27	17.22	0.67	4.84	188.07	28.28	94.16	14.38	0.68	4.85
T <sub>9</sub> , T <sub>5</sub> + T <sub>7</sub>	113.63	27.18	101.94	16.07	0.69	6.46	168.85	32.52	89.06	15.60	0.55	5.15
T <sub>10</sub> , T <sub>6</sub> + T <sub>8</sub>	97.05	24.50	88.95	16.16	0.70	4.81	177.79	30.86	91.39	15.52	0.70	4.81
T <sub>11</sub> , Control	84.13	20.07	61.10	15.46	0.60	3.55	128.37	27.64	86.95	14.00	0.75	3.57
C.D. at 5 %	14.63	2.78	25.87	1.54	0.17	1.23	27.86	2.82	15.57	1.16	N.S.	1.23
S.Em (±)	4.92	0.93	8.71	0.51	0.05	0.41	9.37	0.95	5.24	0.39	0.08	0.41

\* N.S. – Non Significant



### Fruit size

In both seasons, the PGRs had a major impact on all of the fruit's characteristics (Table 3). In the *ambe bahar*, Cycocel 1000 ppm in combination with uracil 25 ppm produced large fruits with a weight of 197.6 g and a length of 6.6 cm, Cycocel 1500 with a width of 6.9 cm, and Cycocel 1000 ppm with a large volume (162.7 mL). The highest values of all four measurements were obtained with Cycocel 1500 in the *hastha bahar*. The larger fruit size obtained with Cycocel (on all four scales, namely weight, length, width, and volume) was due to photosynthates being guided to developing fruits as a result of Cycocel's suppression of vegetative growth by blocking gibberellin synthesis. The same results were observed in olive cv. 'Pendolino' by Arun *et al.* (2016). The increase in fruit volume was a clear product of the increase in length and width, which was most likely caused by increased levels of endogenous auxins, which promote cell elongation. These findings are similar to those made by Kurian and Iyer (1992) in the mango cv. 'Alphonso' and Pandey *et al.* (2001) in the guava.

### Fruit quality

The PGRs had a big impact on the fruit production (Table 4). Cycocel 1000 ppm in combination with uracil 25 ppm produced the highest total aril weight (113.6 g), 100-aril weight (27.18 g), and maximum juice (101.94 g), as well as the highest anthocyanin content (6.46 mg 100g) in the *ambe bahar*, while Cycocel 1500 ppm alone produced the sweetest (high TSS of 19.96 °B) and least acidic juice fruits (0.41 percent). On all counts, Cycocel 1500 ppm was the best in the *hastha bahar*. It resulted in higher total aril weight, 100-aril weight, TSS, and least acidity, with the exception of colour, where plants treated with nitrobenzene 1.5 mL / L per plant had the highest anthocyanin content. The larger fruits, as a result of a better physiological response in terms of the supply of water, nutrients, and other metabolites necessary for proper growth and development, resulted in heavier arils following the application of Cycocel. Varasteh *et al.*, (2008) made similar observations in pomegranate. The increase in 100-aril weight may be due to larger cells and intercellular spaces – a Cycocel effect – combined with increased deposition of water, sugars, and other soluble solids as a result of metabolite translocation into the fruit. Anawal *et*

*al.*, (2015) found similar results in the pomegranate cv. 'Bhagwa'. Apart from heavier arils, the increase in juice quantity was most likely due to larger and heavier fruits, as stated by Bankar and Prasad in pomegranate cv. 'Ganesh' (1992). The translocation of sugars and water to the arils tends to be the cause of the rise in juice volume. The proportion of seeds may have decreased in proportion to the increase in the amount of juice as the water content of arils increased. Supe and Saitwal (2016) found similar findings in pomegranate cv. 'Mridula.' The higher Brix reading after using Cycocel was most likely due to increased metabolism, as shown by higher osmotic pressure in cells, which appears to increase the accumulation of solutes including ions and sugars (Singh, 2016). Another explanation may be that Cycocel-treated plants have a more effective photosynthetic apparatus (leaves), resulting in higher TSS content, as Bikramjit *et al.*, (2012) found in pomegranate. The rise in total anthocyanins after the use of nitrobenzene and Cycocel was most likely due to the continued synthesis of phenolic compounds after harvest to keep the ripening process going. The activity of enzymes involved in the anthocyanin synthesis pathway, such as phenylalanine ammonia lyase (PAL) and UDP-glucose, flavonoid-3-O-glucosyl transferase, may also play a role in the increase in anthocyanin concentration after harvest (GT). Gil *et al.*, (1995) also obtained similar findings in grape.

### Conclusion

Foliar spray showed that uracil 50 ppm in the *ambe bahar* led to production of higher number of hermaphrodite flowers (264.7) and fruits (154.0) and yield (27.1 kg) per plant whereas Cycocel at 1000 ppm in combination with uracil at 25 ppm led to increased fruit size (197.6 g), juice content (102 g), TSS (19.96 °B), and aril colouration (anthocyanin content 6.46 mg 100g<sup>-1</sup>). In the *hastha bahar*, Cycocel at 1500 ppm proved superior on almost every count (number of hermaphrodite flowers, percentage of fruit set and number of fruits per plant). Therefore, a foliar spray of Cycocel 1000 ppm and uracil 25 ppm combination in winter or Cycocel 1500 ppm, in the *hastha bahar*, is recommended for fetching high fruit yield and better-quality fruits of pomegranate in India.

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