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Exploitation of Plant Growth Substances for Improving the Yield and Quality of Pomegranate under Ultra High Density Planting

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A B S T R A C T

The present investigation was conducted in the Department of Fruit Crops, HC & RI, TNAU, Coimbatore during the year 2011 to 2013 at Jain Irrigation Systems Pvt. Limited Farms, (JISL), Udumalpet, to investigate the response of plant growth substances on yield and quality of pomegranate cv. Mridula under ultra high density planting (UHDP). The experiments was laid out in randomized block design with nine treatment of plant growth substances *viz.*, NAA 10 ppm, GA_3 50 ppm and KNO_3 1 % and combination of each two and three including of water spray and were sprayed three times from 150 days after pruning subsequently, at 30 and 60 days after first spray and absolute control were maintained. Three replications were followed to investigate various yield and quality attributes of three year old TC pomegranate *(Punica granatum L.)* cv. Mridula grown under UHDP. The results revealed that application of NAA 10 ppm + $GA_3$50 ppm was recorded the maximum number of fruits per plant (65.11), average fruit weight (272.5 g), Fruit volume (290 cc), fruit length (7.7 cm), fruit diameter (7.9 cm), number of aril per fruit (670), total aril weight per fruit (186.2 g), 100 aril weight (25.85 g), aril recovery (25.85 %), total seed weight (20.23 g), fruit yield / plant (17.74 kg), as compared with water spray. In regards to the quality attributes application of (GA_3 50 ppm + KNO_3 1 %) registered the highest values for total sugar (9.01 %), reducing sugar (7.35 %), total soluble solids (16.2 %) and anthocyanain (18.85 %) content as compared with water spray. Therefore application of three sprays of NAA 10 ppm + GA_3 50 ppm starting from 150 days after pruning and subsequently at 30 days interval resulted in the highest yield attributing characters whereas, the quality of pomegranate was increased by application of GA_3 50 ppm + KNO_3 1 % . It could be considered as best combination for getting increased yield and quality for three years old TC pomegranate cv. Mridula.

Introduction

Pomegranate (*Punica granatum* L.) belongs to the family Punicaceae. It is a shrub or small tree attaining a height of 4–10 m. There are three main seasons of flowering known as Ambe bahar, Mrig bahar and Hasta bahar. Flowers appear as singles or in small clusters, generally of 2-6 flowers occasionally at the end of the branch but sometimes on the auxiliary buds. Out of 25–30 buds, usually 3–5 flowers develop. They may appear on last season's growth with the same arrangement and occasionally only on the last season's growth, but most are borne on the current year's growth. The flowers are bisexual and

the fruit is a berry (Still, 2006), the fruit is a fleshy inferior berry, with a thick skin enclosing the edible parts, with cavities (locules) of 4–15, separated by membranous partitions (carpellar membranes). The interior is filled with many fleshy seeds prismatic in shape. The numerous seeds are each surrounded by juicy, sub acid pulp (arils) which is the edible part. There are 1200-1300 seeds in the large-sized fruit with less in the smaller fruit. The fruit size can differ from 6–12 cm in diameter and has a hard, tough skin leaves are simple and opposite with entire margins and deciduous in nature.

Pomegranate is non climacteric fruit therefore harvesting period is important to control the quality of fruits. Farmers need to know a suitable time for harvesting of pomegranates. Hence, physicochemical properties of fruits on tree by counting days after flowering are investigated. The correlation of physicochemical properties and maturity index is considered to determining of the suitable time for harvesting of pomegranates.

Fruit rind colour is an attribute that determines consumers' behaviour, and it is accepted as one of the most important external quality parameters (Ercisli, 2007). One of the most important quality characteristics of pomegranate is the red pigmentation of seeds and juice. This red colour depends on anthocyanin concentration and on the chemical structure of the individual anthocyanin (Holcroft *et al.*, 1998).The physico-chemical characterization of pomegranate samples is important because the physico-chemical composition is closely related to the quality and preservation of products. Pomegranate fruit is consumed directly as fresh arils as well as fresh juice (Al-Said *et al.*, 2009).

Beneficial effect of various plant growth regulators have been reported on many fruit crops and proved beneficial for improving quality and yield. Mostly the plant growth substances have been used for various beneficial effects such as promoting root growth, number of flowers, increasing the fruit set, fruit size and quality for inducing early uniform fruit ripening. Although, the effect of foliar applied chemicals on yield and fruit quality have been studied by many workers the information of such effect on pomegranate fruit is very scanty. Hence, the present investigation was undertaken to study the response of plant growth regulators on flowering, yield and quality of pomegranate cv. mridula under ultra high density planting.

The plant growth regulators (PGRs) are the chemical substances, when applied in small amounts modify the growth of plants either by stimulating or inhibiting part of the natural growth regulatory system. They play an important role in enhancing the source sink relationship and stimulate the translocation of photo assimilates to sink organs. From late 1980 onwards, uses of plant growth regulators have assumed significance in increasing the yield of horticultural crops by overcoming the physiological constraints (Prabakaran, 2002). Plant hormones play a vital role in improving female flower production and fruit set in a number of crops, thereby ensuring their full productive potential (Taiz and Zeiger, 2002). In accordance with this contention, the present study was conducted to understand the influence of certain plant growth regulating chemicals in improving the yield and quality potential of pomegranate, besides overcoming the physiological constraints.

Materials and Methods

The experimental field was located at JISL Farms, Elayamuthur, Udumalpet, Thirupur District which is about 90 km away from Coimbatore. The present experiment was carried out in three years old tissue cultured

pomegranate plants of cv. Mridula during the year 2011 to 2013. The spacing adopted was 3x2 m, with a plant population of 1667 plants ha^{-1}. The experiment was laid out with five levels of NPK in randomized block design (RBD) and replicated three times. In this study Ambe bahar (January–February) flowering season was used and observation registered.

The above growth regulators were sprayed initially at 150 days after pruning (flowering to fruit set stage). Subsequently two sprays were given at 180 and 210 days after pruning (fruit development stage). The observations were taken from five uniform and randomly selected plants for each treatment. The observations namely, number of fruits per plant, average fruit weight, fruit volume, fruit length, fruit diameter, number of aril per fruit, total aril weight per fruit, 100 aril weight, aril recovery, total seed weight, fruit yield / plant, total sugar, reducing sugar, total soluble solids and anthocyanain content were recorded five representative plants.

Methodology

Total number of fruits per plant: The fruits borne on the plant were tagged individually, counted at the time of harvest and expressed in number.

Average fruit weight: Twenty fully matured fruits from each of the treatment combinations were randomly selected at field level and each fruit was weighed on electronic balance and average weight of the fruit per treatment was computed in gram (g).

Fruit volume: The fruit volume was calculated by water displacement method in twenty fruits and the average was expressed in cubic centimetre (cc).

L/S of fruit length: The measurement of fruit length was made on the polar axis, that is between the apex and end of the stem along the curve by using thread and expressed in centimetre (cm).

Fruit diameter: The fruit diameter was measured at the mid length of the fruit using thread and expressed in centimetre (cm).

Aril recovery

The percentage of aril recovery was estimated and expressed in per cent (%)

$$\text{Percentage of aril recovery} = \frac{\text{Average aril weight of fruit}}{\text{Mean fruit weight}} \times 100$$

Fruit quality analysis

Total Soluble Solids (TSS): The total soluble solid of the fruit juice was determined by using hand refractometer (Erma. Tokyo – A^{O} 32) and the results were expressed in °Brix.

Total sugars: The total sugars content was estimated by using the method suggested by Hedge and Hofreiter (1962) and expressed in per cent.

Reducing sugars: The reducing sugars content was estimated by following the method suggested by Somogyi (1952) and expressed in per cent.

Anthocyanin content: The anthocyanin content of aril was estimated as per the method of Swain and Hillis (1959) and expressed in mg $100g^{-1}$.

Yield per plant: Yield per plant was arrived at by harvesting the total number of fruits produced from selected plants individually and expressed in kilogram (kg).

Results and Discussion

Effect of plant growth regulators on yield and yield contributing characters

Yield depends on environmental (E), genetic (G) factors and strong G * E interactions (Chapman, 2008). In the present study, the economic yield attributing characters *viz*., number of fruits per plant, average fruit weight, fruit volume, fruit length, fruit diameter, number of aril per fruit, total aril weight per fruit, 100 aril weight, aril recovery, total seed weight and fruit yield / plant was significantly increased by spraying of plant growth substances. Among the different treatments tried, sprayed with combination of NAA 10 ppm + GA_3 50 ppm produced the highest number of fruits (65.11), average fruit weight (272.5 g), fruit volume (290 cc), fruit length (7.7 cm), fruit diameter (7.9 cm), number of aril per fruit (670), total aril weight per fruit (186.2 g), 100 aril weight (25.85 g), aril recovery (25.85 %), total seed weight (20.23 g) and fruit yield / plant (17.74 kg) followed by combination of NAA 10 ppm + GA_3 50 ppm+1% KNO_3 (Table 1).

The lowest yield parameters were recorded by control (T_1) water spray. This might be due to production of highest number of hermaphrodite flowers per plant and might be due to reduced fruit drop and higher fruit retention. On the other hand (Reddy *et al.*, 2012) reported that in pomegranate cv. Ganesh the maximum numbers of fruits (63.17) were obtained when NAA alone was applied at 40 ppm followed by GA_3 at lower concentration *i.e.* 25 ppm produced 52.33 numbers of fruits. Exogenous application of gibberellic acid appears to favour various growth parameters resulting in production of robust plant that can produce and support a large number of inflorescences. As gibberellic acid plays a major role in regulating assimilation and supply to developing sink (Taiz and Zieger, 2002), this treatment favoured the production of maximum number of fruits. A significant increase in fruit length and fruit diameter obtained may be attributed due to nature of auxins (NAA) to stimulate cell division, cell elongation and membrane permeability to water uptake (Chaudhary *et al.*, 2006). Gibberellins are involved in cell division and cell elongation. They are known to influence fruit size (Zhang *et al.*, 2011).

Gibberellic acid is also reported to promote growth by increasing plasticity of the cell wall followed by the hydrolysis of starch into sugars which reduces the cell water potential, resulting in the entry of water into the cell and causing elongation (Richard, 2006). With respect to fruit weight of pomegranate (Reddy *et al.*, 2012) and (Ghosh *et al.*, 2009) obtained higher fruit weight in the cv. Ganesh and in the cv. Ruby by the application of GA_3 75 ppm and GA_3 10 ppm.

The results of the present study revealed that the plants sprayed with NAA 10 ppm + GA_3 50 ppm produced the maximum fruit weight (272.5g) followed by combination of NAA 10 ppm + GA_3 50 ppm+1% KNO_3. Beneficial role of NAA and GA_3 in improving fruit weight was also reported by (Pawar *et al.*, 2005) in Pomegranate. Positive role of auxins like NAA along with GA_3 application on fruit weight could be explained from the fact that these are associated with cell division and cell enlargement accompanied by increased supply of photosynthates to the developing berries. Weaver, 1972 and Ghosh *et al.*, 2009 reported that NAA 10 ppm recorded a maximum fruit weight of 29.4 g in Aonla. At higher concentration, the weight of the fruit was reduced. Source, strength and activity and translocation efficiency are the major contributors for better fruit filling, provided the soil moisture and growing environment are not adverse.

Table.1 Effect of plant growth substances on number of fruits per plant, average fruit weight (g), fruit volume (cc), fruit length (cm), fruit diameter (cm), number of arils per fruit, total aril weight (g), 100 aril weight (g), aril recovery (%), total seed weight (g) and yield per plant (kg) of Pomegranate cv. Mridula under UHDP

Treatment	Number of fruits per plant	Average fruit weight (g)	Fruit volume (cc)	Fruit length (cm)	Fruit diameter (cm)	Number of arils per fruit	Total aril weight (g)	100 aril weight (g)	Aril recovery (%)	Total seed weight (g)	Yield per plant (kg)
T_0	47.89	235.2	225	6.5	7.3	628	145.9	22.29	62.0	12.76	11.26
T_1	40.22	224.2	240	6.4	6.6	592	128.4	21.65	57.3	11.86	9.02
T_2	58.33	249.4	265	6.9	7.1	645	151.4	24.48	60.7	12.35	14.55
T_3	50.56	251.6	270	7.0	7.2	650	154.7	24.90	61.5	13.61	12.72
T_4	52.00	243.5	255	6.9	7.0	642	148.2	22.71	60.9	12.98	12.66
T_5	65.11	272.5	290	7.7	7.9	670	186.2	25.85	68.3	20.23	17.74
T_6	53.67	249.1	200	6.8	7.0	623	152.6	24.93	61.3	19.11	13.37
T_7	50.67	250.6	205	6.8	7.1	631	160.1	23.20	63.9	19.03	12.70
T_8	59.67	261.3	275	7.4	7.6	659	170.6	25.34	65.3	19.86	15.59
SEd	**1.113**	**6.086**	**6.214**	**0.104**	**0.168**	**13.873**	**3.042**	**0.533**	**1.410**	**0.363**	**0.275**
CD (0.05)	**2.361**	**12.903**	**13.173**	**0.222**	**0.356**	**29.409**	**6.449**	**1.131**	**2.990**	**0.770**	**0.584**

Table.2 Effect of plant growth substances on total sugar (%), reducing sugar (%) total soluble solids (^{o}Brix), and anthocyanin (mg 100 g -1) content of Pomegranate cv. Mridula under UHDP

Treatment	Total sugar (%)	Reducing sugar (%)	Total soluble solids (^{o} Brix)	Anthocyanin (mg 100 g $^{-1}$)
T_0	8.90	7.30	16.0	16.3
T_1	8.46	7.14	15.5	15.49
T_2	8.58	7.27	15.0	16.45
T_3	8.75	7.30	15.2	16.79
T_4	8.29	7.24	16.0	18.04
T_5	8.86	7.21	15.6	16.58
T_6	8.40	7.25	15.8	17.74
T_7	9.01	7.35	16.2	18.85
T_8	8.95	7.26	15.8	18.13
SEd	**0.187**	**0.103**	**0.318**	**0.412**
CD (0.05)	**0.396**	**0.220**	**0.674**	**0.875**

As observed in the present study, the yield per plant (17.74 Kg in three year old pomegranate plants under UHDP) was maximum in the treatment with the application of NAA 10 ppm + GA_3 50 ppm. These results indicated that growth and physiological parameters were favorably influenced by these growth promoters with consequent increases in yield. Similar to the present findings, the influence of NAA and GA_3 on increasing the yield of pomegranate cv. Ganesh was reported by Reddy *et al.,* 2012 and they confirmed that increased number of fruits per plant might have contributed towards increase in yields due to growth regulators application.

Effect of plant growth substances on quality parameters

Pomegranate has been of recent interest for its nutritional, chemical, and antioxidant characteristics. The composition of mineral nutrients and chemical properties of fruit differs depending on cultivar, growing region, climate, maturity, and cultural practice (Mirdehghan and Rahemi, 2007). Minerals and plant growth hormones affect production and fruit quality either directly or indirectly. Most effects are indirect and act via alteration of vigor and capacity, and thereby the partitioning of primary and secondary photosynthetic metabolites such as carbohydrates, organic acids, proteins, growth regulators and flavor compounds (Khayyat *et al.*, 2013).

Fruit quality is one of the important goals in any production system besides targeting for maximum fruit yield per unit area. In pomegranate, apart from average fruit weight, the quality is determined by total sugar, total soluble solids, anthocyanin and sugar acid ratio. As the pomegranate fruit matures on the plant, a reduction in the titrable acidity and parallel increase in TSS, pH, and colour intensity is observed (Kader, 2006).

The results of the present experiment on improving the quality of pomegranate fruits indicated that spraying thrice with GA_3 50 ppm + KNO_3 1 % had recorded the maximum total sugar (9.01 %), reducing sugar (7.35 %), total soluble solids (16.2 %) and anthocyanain (18.85 %) content and the lowest was recorded in control (T_1) water spray. This could be explained from the light of findings of Ghosh *et al.*, 2009 and Pandey, 1999 who reported that improvement in TSS of fruits due to auxins (NAA, 2, 4-D) and GA_3 spray

may be due to the fact that application of these growth regulators after fruit set probably improved the physiology of leaves, thereby causing better translocation of vital components in the fruit followed by assimilation and utilization of photosynthates by the developing fruit (Table 2).

Further, the sugar accumulation and TSS content depends on the photo assimilate production and its movements from the source leaves to sink.

The supplementary sprays of nutrients and plant growth regulator had stimulating effect on photo assimilate production and assimilate transport. The importance of plant growth regulators and nutrient spray treatments in improving the quality of berries was well established from the studies conducted elsewhere for total soluble solids (Warusavitharana *et al.,* 2008).

From the above results it can be concluded that the application of three sprays with NAA 10 ppm + GA_3 50 ppm starting from 150 days after pruning and subsequently at 30 days interval resulted in high yield and yield attributing characters whereas, the quality of pomegranate was increased by application of GA_3 50 ppm + KNO_3 1 % in combination with 50 per cent recommended dose of fertilizers through fertigation (250:62.5:62.5 g NPK $plant^{-1}$ $year^{-1}$).

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