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Influence of NAA and Nutrient levels on flowering and physicochemical characteristics of Pomegranate (*Punica granatum* L.)

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Abstract
Pomegranate (*Punica granatum* L.) is one of the famous table fruits mainly cultivated in tropical and sub-tropical eco-system. It is a newly introduced as alternate commercial fruit crop against Nagpur mandarin in Chhindwara district of Satpura plateau region of M.P. during 2012. One of the major problems under this condition is that cv. Bhagwa exhibits heavy flowering and fruit drop by increasing the fruit set and fruit retention. Plant growth regulators are reported to play a significant role in pomegranate (Chaudhari and Desai, 1993). A field experiment was conducted to investigate the effect of NAA and Nutrient levels on fruit retention and yield attributes of Pomegranate (*Punica granatum* L.). The experiment was conducted on pomegranate on 7-year old Bhagwa cultivar at a spacing of 12 x 8 ft. at JNKVV, Krishi Vigyan Kendra, Chhindwara (M.P.) India during ambia bahar of pomegranate. The investigation was carried out during year (2019-20 and 2020-21). The experiment consisted of eighteen treatments combination include three level of recommended dose of fertilizers as soil application (100%, 75% and 125% RDF) with three level of NAA (0ppm, 10ppm and 20ppm) and drip fertigation (15 days and 30 days interval) with three replications under factorial randomized block design. The present investigation revealed that maximum fruit weight, fruit length, fruit breadth, no. of flower/shoot, and minimum days to 50% flowering was recorded in treatment T_{13} (100% RDF + NAA 20 ppm + fertigation 15 days interval) followed by in T_7 (100% RDF + NAA 10 ppm + fertigation 15 days interval), maximum days to 50% flowering was recorded under treatment T_6 (125% RDF + 0ppm NAA + fertigation 30 days) and maximum acidity (%) was recorded under T_{18} (125% RDF + 20ppm NAA + fertigation 30 days). Whereas the lowest fruit weight, fruit length, fruit breadth, no. of flower/shoot and acidity (%) were recorded under treatment T_4 (75% RDF + 0ppm NAA + fertigation 30 days intaval) during both the years and in pooled analysis. Chemical fertilizer (N, P, K) and plant growth hormone (NAA) significantly effected on fruit retention and quality of pomegranate fruits.

Keywords: Pomegranate, NAA, fertilizer and physicochemical quality

Introduction
Pomegranate (*Punica granatum* L.) is valued highly for its delicious edible fruits are rich in sugars, vitamins, polysaccharides, polyphenols, and minerals (Ferrara *et al*., 2014). Pomegranate tree is also cultivated for its pharmaceutical and ornamental usage. It has high adaptability to versatile conditions especially stress conditions (Haggag and El Shamy, 1987). Pomegranate trees are favor for semi-arid climates (El-Falleh *et al*., 2009). It is one of the esteemed dessert fruit and is very much liked by people for its cool refreshing juice, taste and being highly valued for its nutritional and medicinal properties. Aanthocyanins from pomegranate fruit have been shown to have higher antioxidant activity than vitamin E (tocopherol), vitamin C (ascorbic acid) or carotene Shukla *et al*. (2008) [16]. Moreover, commercial pomegranate juice has been shown to have three times higher antioxidant activity than green quality such as nitrogen, phosphorus, potassium and tea and red wine Gil *et al*. (2000) [5]. In India it is cultivated over an area of 283.00 thousand hectare with a production of 3186.00 thousand MT (NHB, 2019-20). In India, pomegranate is commercially cultivated in Maharashtra and parts of Karnataka where good quality fruits are produced due to dry and hot climate. Plant growth regulators have been used for beneficial effects like fruit size, appearance and aril quality i.e. to improve physical characteristics and fruit quality of pomegranate Anawal *et al*. (2016) [3]. Its intensive cropping involving bahar treatment (manipulation of flowering and fruit setting involving plant hormones) without proper nutrient management is deteriorating plant health and making the plants susceptible for several biotic and abiotic stresses (NRCP, 2011) [11]. Hence, there is need for balanced nutrient application and enhancing its availability in soil that stimulates their uptake and assimilation by pomegranate. Among the various factors responsible for increasing the crop production, the use of balanced fertilizer at right time, right quantity, source and method plays a vital role in

enhancing the productivity. Since, pomegranate is high value crop most of farmers are following drip irrigation method and are in need of proper fertigation schedule for enhancing crop productivity. Further, the time of nutrient application has also known to have significant influence on pomegranate yield and quality *viz*., nitrogen on flowering pattern, potassium on fruit colour, calcium and boron on fruit cracking etc. (Gosh *et al*., 1996) [4]. NPK fertilization improved fruit size, TSS and yield 'Singh *et al*. (1988). Fertilization especially with nitrogen is one of the important management tools for increasing crop yield. Application of controlled-release fertilizers seem to be very effective on improving the growth and productivity of most fruit trees. This is attributed to the continuous amendment of N during all growth and fruit development stages as well as release their own N at a longer period and at the critical date of fruit development (Koo, 1988; Wang and Alva, (1996) and El-Salhy *et al*. (2013). The present experiment was taken up to study the significant effect of NAA, fertilizer and fertigation treatments on growth and yield parameters of pomegranate cv. Bhagwa.

Materials and Methods

The experiment was carried out at JNKVV, Krishi Vigyan Kendra, Chhindwara (M.P.) India during 2019-20 and 2020-21 on 7-year-old Bhagwa variety of pomegranate at spacing of 12 x 8 ft. For this investigation, plant were selected uniform vigour and size. Through out investigation, all of the trees were kept on a same cultural schedule. Each plant received the necessary amount of manure and fertilizer, as well as light irrigation. Following that, a drip irrigation system was used to provide regular irrigation. With three replications and eighteen plants per replication, the experiment was set up in a Factorial Randomized Block Design. There were eighteen treatments with NAA, prescribed fertilizers doses, and fertigation, included NAA at 0, 10 and 20 ppm, RDF at 100, 125 and 75 percent, and fertigation at 15 and 30 days intervals. At the start of the experiment, fertilizer application as a basal dose, and fertigation was started after flower initiation at 15 and 30 days intervals, and NAA was sprayed twice, once at the flower initiation stage and again at the 50% flowering stage.

Result and Discussion

Fruit Weight

Fruit weight was significantly influenced by the plant growth regulator with combination of different level of nutrient application (NPK). It can be deduced from the data presented in Table 1 that treatment combination (T_{13}) yet significantly increased the fruit weight (270.37, 271.38 and 270.87) over all the remaining treatment combinations, while minimum fruit weight was recorded (230.33, 231.41 and 230.87) under the treatment combination (T_4) in both year and as well as pooled data. In the present study the application of NAA 20ppm significantly increased the fruit weight and volume. This may be due to immediate absorption of auxins, which increased the endogenous auxin level that resulted in cell elongation, and further accelerated the development of fruits. Similarly responses in fruit weight was observed by Hussein *et al*. (1994) [12] in pomegranate by using NAA 20ppm. Adi and Prasad (2012) [1] studied the positive influence of NAA on fruit length, diameter in pomegranate cv. Ganesh and Anawal *et al*. (2015) [2] in Bhagwa. Using N, P and K at balancing rate was favourable in enhancing flowering and fruit setting behaviour of the trees at the expense of vegetative growth characters. The ratio between total carbohydrate and N was beneficially adjusted when the N, P and K fertilizers were added via balanced rate. Under such conditions the number of flowers was greatly formed. Most nutrients were reduced due to using N, P and K. this is due to their exhaustion or depletion on forming growth and fruiting portions. The beneficial effect of N, P and K especially when applied at balanced rate on growth, and fruiting of Wounderful pomegranate trees are in harmony with those obtained by Firak and Deolanker (2000), Li (2000), Dhillon *et al*., (2009) and El- Sayed (2013) on different pomegranate cvs. The same trend was observed in another deciduous fruit crops by Elkhawaga (2011), Von- Bennewitz *et al*., (2011); Milosevic *et al*., (2013) and Kumar- and Ahmed (2014).

Fruit Length

It is evident from the data (Table 1) that the fruit size measured in terms of fruit length was significantly influenced by the plant growth regulator with combination of fertilizer application. The data indicates that the mean fruit length values in first year, second year and pooled under various treatments combination. The maximum fruit length was recorded (73.44, 72.97 and 73.21) in treatment combination T_{13} (100% RDF + 20ppm NAA + fertigation 15 days interval) followed by treatment combination T_7. Further, the minimum fruit length was recorded (70.30, 69.90 and 70.10) in treatment combination T_4 (75% RDF + 0ppm NAA + fertigation 30 days interval) in both year as well as pooled data respectively. In the present study the application of NAA 20ppm significantly increased the fruit length. This may be due to immediate absorption of auxins, which increased the endogenous auxin level that resulted in cell elongation, and further accelerated the development of fruits. Similarly Adi and Prasad (2012) [1] studied the positive influence of NAA on fruit length, diameter in pomegranate cv. Ganesh and Anawal *et al*. (2015) [2] in Bhagwa. This might due to continuous supply of major nutrients through fertigation till fruit enlargement stage that resulted in maintenance of high nutrient availability throughout the crop growth hence, promoting better fruit size and weight. These results are also in accordance with the findings of Shirgure *et al*. (2001) [13] , Mahalakshmi *et al*. (2001) [8] and Thakur and Singh (2004) [15], who observed increase in fruit size and weight with increasing level of N, P, K fertilizers with fertigation.

Table 1: Effect of NAA and Nutrient levels on fruit weight, fruit length and fruit diameter

Treatment combination		Fruit weight (g)			Fruit length (mm)			Fruit diameter (mm)		
		2020	2021	pooled	2020	2021	pooled	2020	2021	pooled
T1	100% RDF + 0ppm NAA + fertigation 15 days	264.45	265.38	264.91	72.70	72.26	72.48	72.06	72.58	72.07
T2	100% RDF + 0ppm NAA + fertigation 30 days	262.23	263.12	262.68	72.12	71.62	71.87	71.55	71.76	71.65
T3	75% RDF + 0ppm NAA + fertigation 15 days	232.18	233.20	232.69	70.67	70.13	70.40	70.22	70.41	70.32
T4	75% RDF + 0ppm NAA + fertigation 30 days	230.33	231.41	230.87	70.30	69.90	70.10	70.08	70.36	70.22
T5	125% RDF + 0ppm NAA + fertigation 15 days	250.11	225.62	237.86	71.88	71.40	71.64	71.47	71.73	71.59
T6	125% RDF + 0ppm NAA + fertigation 30 days	249.52	250.62	250.07	71.15	70.71	70.93	71.10	71.29	71.19
T7	100% RDF + 10ppm NAA + fertigation 15 days	269.36	270.53	269.95	73.12	72.73	72.93	73.16	73.48	73.32
T8	100% RDF + 10ppm NAA + fertigation 30 days	264.12	265.25	264.69	71.86	71.27	71.56	71.56	71.83	71.70
T9	75% RDF + 10ppm NAA + fertigation 15 days	235.83	236.86	236.34	70.86	70.17	70.52	70.50	71.08	70.79
T10	75% RDF + 10ppm NAA + fertigation 30 days	231.11	232.25	231.68	70.53	70.07	70.30	70.82	70.40	70.33

T11	125% RDF + 10ppm NAA + fertigation 15 days	251.57	252.56	252.06	71.93	71.48	71.71	71.45	71.67	71.56
T12	125% RDF + 10ppm NAA + fertigation 30 days	250.53	251.48	251.01	71.35	70.94	71.15	71.21	71.47	71.34
T13	100% RDF + 20ppm NAA + fertigation 15 days	270.37	271.38	270.87	73.44	72.97	73.21	73.98	74.38	73.34
T14	100% RDF + 20ppm NAA + fertigation 30 days	263.61	264.49	264.05	72.17	71.71	71.94	71.56	71.76	71.91
T15	75% RDF + 20ppm NAA + fertigation 15 days	238.83	239.92	239.38	71.07	70.58	70.83	70.84	70.73	70.79
T16	75% RDF + 20ppm NAA + fertigation 30 days	240.51	241.49	241.00	70.93	70.41	70.67	70.25	71.03	70.93
T17	125% RDF + 20ppm NAA + fertigation 15 days	265.61	266.55	266.08	72.74	72.24	72.49	72.62	72.87	72.75
T18	125% RDF + 20ppm NAA + fertigation 30 days	261.55	262.59	262.07	72.00	71.53	71.77	71.44	71.65	71.56
	S.Em+	0.208	0.208	0.487	0.081	0.086	0.106	0.162	0.159	0.157
	CD at 5%	0.592	0.592	1.384	0.229	0.244	0.301	0.459	NS	NS

Fruit diameter

Fruit diameter was significantly affected by application of plant growth hormone NAA with combination of recommended dose of fertilizer in first year and not significantly affected second year and as well as pooled. The data presented in Table 1 the maximum fruit diameter was recorded (73.97, 74.38 and 73.34) in treatment combination T_{13} (100% RDF + 20ppm NAA + fertigation 15 days interval) followed by treatment combination T_7. Further, the minimum fruit length was recorded (70.08, 70.36 and 70.22) in treatment combination T_4 (75% RDF + 0ppm NAA + fertigation 30 days interval) in both year as well as pooled data respectively. In the present study the application of NAA 20ppm significantly increased the fruit length. This may be due to immediate absorption of auxins, which increased the endogenous auxin level that resulted in cell elongation, and further accelerated the development of fruits. Similarly Adi and Prasad (2012) [1] studied the positive influence of NAA on fruit length, diameter in pomegranate cv. Ganesh and Anawal *et al*. (2015) [2] in Bhagwa.

Days to 50% flowering

The application of different level of growth regulators NAA and fertilizer significantly affected the days to 50% flowering of pomegranate. Data presented in table 2 the minimum days to 50% flowering (47.13, 44.00 and 45.67) was recorded in treatment combination T_{13} (100% RDF + 20ppm NAA + fertigation 15 days interval) whereas, the maximum days to 50% flowering (57.67, 52.00 and 54.83) was recorded in treatment combination T_6 (125% RDF + 0ppm NAA + fertigation 30 days interval) in both year as well as pooled. The result on earliness in flowering in this experiment goes with the reports by Kannan *et al*., (2009) in paprika and Bhujbal *et al*., (2013) in sapota who reported that the application of NAA produced significantly minimum number of days for flower initiation.

No. of flowers/shoot

Development of flowers after bahar treatment and the type of flowers are the key factors that govern fruit yield and quality in pomegranate cultivation. Pomegranate is characterized by having both bisexual (hermaphrodite) and functionally male flowers on the same tree, a condition referred to as andromonecy (Wetzstein *et al*. 2015) [34]. Some authors also signify an intermediate type flowers that exhibit weak pistil development (Wetzstein *et al*. 2015) [34] that also have bisexual character. Number of flowers/shoot was significantly influenced by the plant growth regulator (NAA) with combination of different level of nutrient application (NPK). Data presented in Table 2 maximum number of flowers/shoot (4.10, 4.73 and 4.42) was recorded in treatment combination T_{13} (100% RDF + 20ppm NAA + fertigation 15 days interval) whereas, the minimum number of flowers/shoot (2.17, 2.40 and 2.28) were recorded in treatment combination T_4 (75% RDF + 0ppm NAA + fertigation 30 days interval) in both year as well as pooled data. This could be attributed to the supply of N to pomegranate plants with fertigation and basal doses. Abundant nitrogen supply with ample opportunity for carbohydrate synthesis is known to produce vegetative growth and reduce flowering (Corbesier *et al*. 2002). Bernier *et al*. (1981) and Rideout *et al*. (1992) reported wider C:N endogenous ratio promotes flowering in plants while, narrow ratio stimulated vegetative growth. This might have reduced flowering by enhanced vegetative growth during bud differentiation (Corbesier *et al*. 2002). The hermaphrodite flowers that possess positive correlation with fruit yield (Shanmugasundaram & Balakrishnamurthy 2013) were significantly higher in treatments that received balance basal application of N.

Titrable acidity

Titrable acidity content varied not significantly among different treatments combination (Table 2). The maximum acidity (0.41, 0.42 and 0.41) was recorded in treatment combination T_{17} (125% RDF + 20ppm NAA + fertigation 15 days interval) whereas, the minimum acidity (0.36, 0.37 and 0.37) was recorded in treatment combination T_4 (75% RDF + 0ppm NAA + fertigation 30 days interval) in both year as well as pooled. The variation in these parameters could be due to higher K and N content in these treatments. Khayyat *et al*. (2012) reported increased titrable acidity and ascorbic acid content in pomegranate fruit juice with the application of 250 mg L^{-1} $plant^{-1}$ of K during fruit enlargement stage owing to its role in accumulation of higher photosynthates (carbohydrates) in fruits. Further, higher levels of nitrogen stimulate synthesis and catalytic activity of several enzymes and co-enzymes which are instrumental in ascorbic acid synthesis (Boora & Singh 2000, Sheikh & Manjula 2012). Application of plant growth regulator increase the level of NAA with increase tirable acidity similar results was recorded by Ghosh *et al*. (2009) in pomegranate.

Table 2: Effect of NAA and Nutrient levels on days to 50% flowering, no. of flower/shoot and titrate acidity

Treatment combination		Days to 50% flowering			No. of flower/shoot			Titrate acidity (%)		
		2020	2021	pooled	2020	2021	pooled	2020	2021	pooled
T1	100% RDF + 0ppm NAA + fertigation 15 days	49.00	48.33	48.67	2.97	3.53	3.25	0.36	0.38	0.37
T2	100% RDF + 0ppm NAA + fertigation 30 days	53.33	48.67	51.00	2.83	3.17	3.00	0.38	0.39	0.39
T3	75% RDF + 0ppm NAA + fertigation 15 days	53.00	49.33	51.17	2.17	2.40	2.28	0.37	0.38	0.38
T4	75% RDF + 0ppm NAA + fertigation 30 days	54.33	51.00	52.67	2.33	2.43	2.38	0.36	0.37	0.37
T5	125% RDF + 0ppm NAA + fertigation 15 days	55.67	52.00	53.83	2.67	2.73	2.65	0.40	0.41	0.41
T6	125% RDF + 0ppm NAA + fertigation 30 days	57.67	52.00	54.83	2.63	2.77	2.68	0.38	0.40	0.39
T7	100% RDF + 10ppm NAA + fertigation 15 days	48.33	46.33	47.33	3.83	4.33	4.08	0.37	0.39	0.38

T8	100% RDF + 10ppm NAA + fertigation 30 days	51.33	49.00	50.17	2.90	3.17	3.03	0.38	0.40	0.39
T9	75% RDF + 10ppm NAA + fertigation 15 days	51.67	47.67	49.67	2.37	2.53	2.45	0.37	0.38	0.38
T10	75% RDF + 10ppm NAA + fertigation 30 days	53.00	51.00	52.00	2.27	2.53	2.40	0.37	0.38	0.38
T11	125% RDF + 10ppm NAA + fertigation 15 days	55.67	52.00	53.83	2.57	2.80	2.73	0.39	0.41	0.40
T12	125% RDF + 10ppm NAA + fertigation 30 days	57.00	52.00	54.50	2.60	2.73	2.68	0.38	0.40	0.39
T13	100% RDF + 20ppm NAA + fertigation 15 days	47.33	44.00	45.67	4.10	4.73	4.42	0.37	0.39	0.38
T14	100% RDF + 20ppm NAA + fertigation 30 days	50.67	47.33	49.00	3.00	3.20	3.10	0.38	0.39	0.38
T15	75% RDF + 20ppm NAA + fertigation 15 days	54.00	51.00	52.50	2.47	2.57	2.52	0.37	0.39	0.38
T16	75% RDF + 20ppm NAA + fertigation 30 days	50.33	48.00	49.17	2.33	2.57	2.45	0.37	0.38	0.38
T17	125% RDF + 20ppm NAA + fertigation 15 days	55.67	51.33	53.50	3.67	4.03	3.85	0.41	0.42	0.41
T18	125% RDF + 20ppm NAA + fertigation 30 days	56.00	52.00	54.00	2.60	3.03	2.82	0.38	0.40	0.39
	S.Em+	0.358	0.228	0.227	0.141	0.109	0.084	0.006	0.005	0.006
	CD at 5%	NS	0.647	0.659	0.401	0.310	0.238	0.015	0.012	0.016

Conclusion

The application of different level of growth regulators NAA and fertilizer significantly affected on fruit weight, fruit length, fruit diameter, titrable acidity and days to 50% flowering of pomegranate. The present investigation revealed that, it is concluded that treatment combination 100% RDF + 20ppm NAA + fertigation 15 days (T_{13}) significant effected in both year as well as pooled than all other treatment combination. The treatment combination 75% RDF + 0ppm NAA + fertigation 30 days (T_4). The present study was therefore, carried out to find the suitability of the plant growth regulators and different nutrient level on the fruit quality and flowering of pomegranate.

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