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Effect of NAA and nutrient levels on fruit retention, yield and quality of pomegranate (*Punica granatum* L.)

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Abstract
To investigate the effect of NAA and Nutrient levels on fruit retention, yield attributes of Pomegranate (*Punica granatum* L.). The experiment was laid out on 7-year old Bhagwa plantation at a spacing of 12 x 8 ft. at JNKVV, Krishi Vigyan Kendra, Chhindwara (M.P.) India during (2019-2020 and 2020-2021) out. 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 retention (%), TSS (^{0}Brix), Total sugar (%), Reducing sugar (%), no. of fruits/plant and fruit yield kg/plant was recorded under T_{13} (100% RDF + NAA 20 ppm + fertigation 15 days interval) followed by T_7 (100% RDF + NAA 10 ppm + fertigation 15 days interval) and the minimum fruit retention %, TSS, Total sugar, Reducing sugar, no. of fruits/plant and fruit yield kg/plant was recorded in treatment T_4 (75% RDF + 0ppm NAA + fertigation 30 days) 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, fruit retention, yield and chemical composition

Introduction
Pomegranate (*Punica granatum*. L), known as "Dadima" in Ayurveda is an important fruit crop in arid and semiarid region. Fruits are large round and modified berry with tough golden or orange rind. Seeds are numerous surrounded by acidic juicy pulp known as 'aril' which is an edible portion. Dried seeds with pulp are called Anar-dana which is an important condiment. It has high demand in internal markets as well as export potential owing to its anti-oxidant values. It is grown for its delicious and juicy pink aril (outer growth of seed) which is eaten fresh (Keskar *et al*., 1993) [16]. The popular crop, native from Iran, belongs to the family, lythraceae. Pomegranate is one of the most important commercial fruit is eaten fresh and also processed for jams, jellies, syrups, pomegranate juice products and is used for medical purposes (Aarabi *et al*., 2008) [5]. Pomegranate is also important in human medicine and its components have a wide range of clinical applications (Lansky and Newman, 2007) [17]. India is the largest producer of pomegranate in the world. The total area under Pomegranate cultivation in India is 209 thousands hectares with annual production of 2442 thousands MT and productivity of 6.6 MT/ha. In MP area under pomegranate 9.23 thousands hectares, production 88.66 thousands MT and productivity 9.63 MT/ha NHB (2017). In India, pomegranate is commercially cultivated in Maharashtra, Karnataka, Andhra Pradesh Madhya Pradesh, Tamil Nadu and Rajasthan (Anonymous, 2013) the most important cultivar in this pomegranate belt is 'Bhagwa' which covers around 80% area under pomegranate in Maharashtra. India's share in the global export market is 6.4 per cent. The importance of synthetic plant growth regulators in achieving higher yield and better quality of horticultural crop has been well recognized in recent time. Plant growth regulators have given encouraging results in case of pomegranate fruit crop (Anawal, *et al*. 2015) [3]. Most of the plant growth regulators exhibit a broad spectrum and thus a single PGR may influence several entirely different processes. Moreover, plant growth regulators enhance the rapid changes in physiological and biochemical characters and improve crop productivity. Those among agricultural practices which may increase the fruit production and improve the quality of several other fruit crops are the applications of plant growth regulators. The effect of NAA on plant growth is greatly dependent on the time of admission and concentration. NAA has been shown to greatly increase cellulose fiber formation in plants. In majority of fruit plants fruit drop is controlled by spraying of NAA in different fruit crops in different concentration. It is applied after blossom fertilization. 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. Nitrogen (N) is known to be one of the most major elements for plant nutrition and development. It plays an important role as a constituent of all proteins, nucleic acids and enzymes. El-Salhy *et al*. (2013). Dhankar *et al*. (2010) [8] observed that fertigation level at 100% recommended dose of fertilizers at alternate day showed significantly higher vegetative growth and physico-chemical characteristics. Improving yield and fruit quality especially N, P and K fertilization.

Materials and Methods

The experiment was carried out on Pomegranate orchard at JNKVV, Krishi Vigyan Kendra, Chhindwara (M.P.) India during year (2019-20 and 2020-21) on 7-year old Bhagwa plantation at a spacing of 12 x 8 ft. Uniform vigour and size were selected for the present study. All the trees were maintained under uniform cultural schedule during the course of investigation. The recommended dose of manures and fertilizers were applied to each plant and light irrigation was given. Regular irrigation was given afterwards through drip irrigation system. The experiment was laid out in a Factorial Randomized Block Design with three replications, and eighteen plants per replication. There were eighteen treatments combination with NAA, recommended dose of fertilizer and fertigation *viz*., NAA at 0, 10 and 20 ppm; RDF at 100, 125 and 75% and fertigation of 15 and 30 days interval. Application of fertilizer as a basal dose at the time of started experiment and fertigation was started after the flower initiation at 15 and 30 days interval and spray of NAA are two time first flower initiation stage and second spray starting at 50% flowering stage.

Result and Discussion

Fruit retention (%)

Fruit retention % were significantly influenced due to the plant growth regulators and fertilizer application during both the years and in pooled analysis. The data presented in Table 1 and which revealed the results the treatment T_{13} was recorded maximum fruits retention (%) (37.17, 36.01 and 36.59) with doses of fertilizer @ 625:250:250 g NPK plant^{-1} (100% RDF) with the combination of plant growth hormone (20 PPM NAA plant^{-1}) and fertigation with (NPK) at 15 days interval and showed the highest significantly than all other treatment combination. The minimum fruits retention (%) in treatment T_4 (29.25, 30.15 and 29.70) in both year and as well as pooled data, were noted with doses of fertilizer @ 468:188:188 g NPK plant^{-1} (75%RDF) with the combination of plant growth hormone @ 0 PPM NAA plant^{-1} and fertigation with (NPK) at 30 days interval respectively.. An increase in fruit retention by NAA application may further attributed to the reason that plants remain physiologically more active to build up sufficient food stock for the developing fruits, ultimately resulted into increased fruit retention. It also enhance the auxin level of plant, thus the increased auxin content reduced the level of abscisic acid in plant and formation of abscission layer of fruit adjacent, which reduces the fruit drop and increased fruit retention. The result was in close conformity with findings of Venkatesan and Kader Mohideen (1994) [27] in pomegranate and similar findings of Singh and Singh (2015) [19] and Jangid *et al*. (2018) [13] in aonla.

No. of fruits/plant

The application of NAA and fertilizer recorded significantly more fruits per tree during the both year as well as pooled data. The data presented in Table 1 showed that treatment combination 100% RDF + 20ppm NAA + fertigation 15 days (T_{13}) significantly enhanced the number of fruit/plant (49.33, 50.33 and 49.83) in first, second and pooled data followed by treat combination 100% RDF + 10ppm NAA + fertigation 15 days (T_7), while the minimum number of fruit/plant (35.00, 36.00 and 35.50) was recorded under combination 75%RDF) + @ 0 PPM NAA plant^{-1} + fertigation 30 days (T_4). The treatment combination100% RDF + 20ppm NAA + fertigation 15 days produced significantly more fruit than other treatment combination. Ghosh *et al*. (2012) [6] application of different doses of NAA @ 15, 20, 25 and 30ppm and observed that sprayed of NAA at 15 ppm was the most effective in reducing the fruit drop at different months after fruit set which resulted in doubling of fruit production as compared to control and improved fruit size in sweet orange. The findings of Singh *et al*. (2006) [14] and Haneef *et al*. (2014) [5] also confirm higher number of fruits with the fertigation treatment in pomegranate.

Yield kg/plant

The data presented in Table 1 which revealed the results obtained for yield kg/plant had significantly influenced due to foliar application of various plant growth regulators and basal dose of fertilizer. Treatment T_{13} recorded maximum yield (13.50) with combination of treatment application @100% RDF + 20ppm NAA + fertigation 15 days followed by treatment T_7 recorded of (12.87) in application with fertilizer 100% RDF + 10ppm NAA + fertigation 15 days. The minimum yield were recorded in treatment T_4 (8.44) application with 75% RDF + 0ppm NAA + fertigation 30 days in both and pooled data. Thereafter, the yield was a little depressed with further increase in K level. The effect of NPK in improving the yield in pomegranate was also confirmed by some workers in earlier studies (Singh *et al*., 1988). The rigid cell wall becomes softened and its plasticity (irreversible capacity to stretch) increases. The loosening of cell wall begins due to dissolution of cell wall material, breaking of chemical bonds between cellulose and other cell wall materials, and fresh synthesis of new cell wall material and its incorporation into existing cell wall. The loosening of cell wall decreases the wall pressure (WP) which is equal to turgor pressure (TP). This action causes greater uptake of water and increase in the size of vacuole; and cell stretches resulting in increasing the yield contributing characters. Our findings are in agreement with those of Reddy (2010) [12] in pomegranate. This may be ascribed to the timely supply of water and nitrogen in the root zone matching with the water and nutrient demands of crop, which in turn promoted the fruit yield. These results corroborated to the findings of Singandhupe *et al*. (2003) and Mandal *et al*. (2007) who observed that split application of N through drip irrigation enhanced yield and nitrogen economy of crop.

TSS (^{0}Brix)

The data presented in Table 2 application of NAA and fertilizer significant affected on TSS in pooled data. The maximum TSS was recorded (15.24) under treatment T_{13} (100% RDF + 20ppm NAA + fertigation 15 days) followed by treatment T_7 (100% RDF + 10ppm NAA + fertigation 15 days) whereas the lowest TSS was recorded (12.18) under treatment T_4 (75% RDF + 0ppm NAA + fertigation 30 days). Rajput *et al.* (2015) reported that the TSS was increased due to its action on converting complex substances into simple ones, which enhanced the metabolic activity in fruits. The increase might be due to an increase in the mobilization of carbohydrates from the source of sink (fruits) by auxins. This might be attributed to the fact that NAA might have increased amylase activity and thus there was quick metabolic transformation of starch into soluble sugars and early ripening

in response to growth substances lead to an increase in TSS. The results of the present study are in agreement with the findings of Agnihotri *et al*. (2013) [4] in guava. Similar results were also obtained by Dubey *et al*. (2002) [4]. Quality of the pomegranate fruits in terms of TSS, aril juice, acidity and sugars are highly influenced with N fertilization up to certain level. Present studies and earlier studies conducted on pomegranate 'Jalore Seedless' (Prasad and Mali, 2003) [19] proved this contention. The studies of these workers conducted at Jodhpur prove that these quality parameters were significantly improved with N level up to 500 g/plant. However, there was decline in quality of the fruits with further increase in N level to 750 g/plant.

Total sugar (%)

The data on effect of foliar application of NAA and basal dose of fertilizer on total sugars of fruits in pomegranate. The data presented in Table 2 the treatment T_{13} (100% RDF + 20ppm NAA + fertigation 15 days) was recorded maximum sugar (13.22) followed by treatment T_7 (100% RDF + 10ppm NAA + fertigation 15 days) were recorded (13.03). The lowest total sugar (10.94) found in treatment T_4 (75% RDF + 0ppm NAA + fertigation 30 days). The increase in total sugars might be due to the fact that growth regulators being helpful in the process of photosynthesis led to the accumulation of oligosaccharides and polysaccharides in higher amount. Besides this, they also regulates the enzymatic activity and the enzymes quickly metabolized the starch into soluble sugars and early ripening in response to growth substances. The combined application of N and K at medium level resulted in significantly more chemical parameters (TSS, sugars, acidity and vitamin-C) as compared to the lower and higher doses of N and K. These results are in conformity with the findings of Fouad *et al*. (5) and Wahdan *et al*. (14), and Salem (10) who have reported the increase in quality parameters of different fruit crops when nitrogen and potassium were applied together in optimum doses. Similar observations were recorded by Agnihotri *et al*. (2013) [4], Dutta and Banik (2007), Kher *et al*. (2005) in guava.

Reducing sugar (%)

Data regarding effect of foliar application of NAA and basal application of NPK, on reducing sugars of fruits of pomegranate are presented in Table 2.The maximum reducing sugar was recorded (11.78) under treatment T_{13} (100% RDF + 20ppm NAA + fertigation 15 days) followed by treatment T_7 recorded (11.62) reducing sugar. The minimum reducing sugar was recorded (9.69) under treatment T_4 (75% RDF + 0ppm NAA + fertigation 30 days) in pooled data. The better sugar content might be obtained by the synergetic effect of plant growth regulators. The research work of Agnihotri *et al*. (2013) [4] is also in line with the present studies. The application of N and K at optimum level of 500 g/plant/year of each was found to be superior as compared to other treatments for enhancing fruit set, yield, and quality. Similar observations were recorded by Kashyap *et al*. (2012) in pomegranate.

Table 1: Effect of NAA and Nutrient levels on fruit retention, no. of fruit and yield of pomegranate

Treatment combination		Fruit retention (%)			No. of fruits/plant			Yield kg/plant		
		2020	2021	pooled	2020	2021	pooled	2020	2021	pooled
T1	100% RDF + 0ppm NAA + fertigation 15 days	35.06	35.83	35.45	45.00	46.00	45.50	11.90	12.21	12.05
T2	100% RDF + 0ppm NAA + fertigation 30 days	34.60	31.40	33.00	37.67	39.33	38.50	9.88	10.35	10.11
T3	75% RDF + 0ppm NAA + fertigation 15 days	30.83	29.97	30.40	36.00	37.33	35.54	8.52	8.87	8.70
T4	75% RDF + 0ppm NAA + fertigation 30 days	29.25	30.15	29.70	35.00	36.00	35.50	8.36	8.71	8.44
T5	125% RDF + 0ppm NAA + fertigation 15 days	32.54	30.46	31.50	37.00	38.33	37.67	8.75	8.12	8.53
T6	125% RDF + 0ppm NAA + fertigation 30 days	31.40	31.13	31.27	37.00	38.33	37.67	9.23	9.61	9.42
T7	100% RDF + 10ppm NAA + fertigation 15 days	36.86	34.42	35.64	47.00	48.33	47.67	12.66	13.08	12.87
T8	100% RDF + 10ppm NAA + fertigation 30 days	33.35	33.87	33.61	40.00	41.33	40.67	10.56	10.96	10.76
T9	75% RDF + 10ppm NAA + fertigation 15 days	31.14	30.57	30.86	37.00	38.33	37.67	8.73	9.08	8.90
T10	75% RDF + 10ppm NAA + fertigation 30 days	30.63	30.83	30.73	37.33	38.00	37.67	8.63	8.83	8.73
T11	125% RDF + 10ppm NAA + fertigation 15 days	32.18	31.33	31.76	37.67	39.00	38.33	9.48	9.85	9.66
T12	125% RDF + 10ppm NAA + fertigation 30 days	32.04	30.89	31.47	37.67	39.33	38.50	9.44	9.89	9.66
T13	100% RDF + 20ppm NAA + fertigation 15 days	37.17	36.01	36.59	49.33	50.33	49.83	13.34	13.66	13.50
T14	100% RDF + 20ppm NAA + fertigation 30 days	34.60	32.89	33.75	44.00	45.33	44.67	11.60	11.99	11.79
T15	75% RDF + 20ppm NAA + fertigation 15 days	31.20	30.89	31.05	37.33	38.33	37.83	8.92	9.20	9.06
T16	75% RDF + 20ppm NAA + fertigation 30 days	30.81	30.83	30.82	37.33	38.33	37.83	8.98	9.26	9.12
T17	125% RDF + 20ppm NAA + fertigation 15 days	36.50	35.15	35.83	41.33	43.00	42.17	10.98	11.46	11.22
T18	125% RDF + 20ppm NAA + fertigation 30 days	31.30	31.35	31.33	38.00	39.00	38.50	9.94	10.24	10.09
	S.Em+	0.127	0.123	0.205	0.457	0.391	0.297	0.117	0.097	0.157
	CD at 5%	0.362	0.351	0.581	1.298	1.109	0.843	0.332	0.276	0.447

Table 2: Effect of NAA and Nutrient levels on TSS (^{0}Brix), total sugar (%) and reducing sugar (%) of pomegranate

Treatment combination		TSS (^{0}Brix)			Total sugar (%)			Reducing sugar (%)		
		2020	2021	pooled	2020	2021	pooled	2020	2021	pooled
T1	100% RDF + 0ppm NAA + fertigation 15 days	13.72	13.50	13.61	12.90	12.45	12.68	11.50	11.03	11.27
T2	100% RDF + 0ppm NAA + fertigation 30 days	13.37	13.00	13.19	12.53	12.10	12.32	11.18	10.87	11.02
T3	75% RDF + 0ppm NAA + fertigation 15 days	12.37	12.10	12.20	12.43	11.00	11.72	10.11	9.73	9.92
T4	75% RDF + 0ppm NAA + fertigation 30 days	12.30	12.00	12.18	11.10	10.77	10.94	9.90	9.47	9.69
T5	125% RDF + 0ppm NAA + fertigation 15 days	12.93	12.65	12.79	11.73	11.30	11.52	10.41	9.97	10.19
T6	125% RDF + 0ppm NAA + fertigation 30 days	12.50	12.20	12.35	11.50	11.10	11.30	10.27	9.83	10.05
T7	100% RDF + 10ppm NAA + fertigation 15 days	15.33	15.09	15.21	13.23	12.83	13.03	11.84	11.40	11.62
T8	100% RDF + 10ppm NAA + fertigation 30 days	13.17	12.79	12.98	12.92	12.43	12.68	11.54	11.05	11.30
T9	75% RDF + 10ppm NAA + fertigation 15 days	12.50	12.20	12.35	11.87	11.53	11.70	10.39	10.23	10.31
T10	75% RDF + 10ppm NAA + fertigation 30 days	12.40	12.11	12.26	11.50	11.13	11.32	9.93	9.83	9.88
T11	125% RDF + 10ppm NAA + fertigation 15 days	13.35	13.11	13.23	12.03	11.70	11.87	10.54	10.33	10.44

T12	125% RDF + 10ppm NAA + fertigation 30 days	13.27	13.00	13.14	11.83	11.43	11.63	10.38	10.10	10.24
T13	100% RDF + 20ppm NAA + fertigation 15 days	15.40	15.08	15.24	13.40	13.03	13.22	12.00	11.57	11.78
T14	100% RDF + 20ppm NAA + fertigation 30 days	14.16	13.56	13.86	12.87	12.60	12.74	11.32	11.23	11.28
T15	75% RDF + 20ppm NAA + fertigation 15 days	12.97	12.75	12.86	12.17	11.83	12.00	10.79	10.53	10.66
T16	75% RDF + 20ppm NAA + fertigation 30 days	12.85	12.62	12.73	11.83	11.50	11.67	10.44	10.17	10.31
T17	125% RDF + 20ppm NAA + fertigation 15 days	13.69	13.83	13.76	13.03	12.87	12.95	11.64	11.47	11.56
T18	125% RDF + 20ppm NAA + fertigation 30 days	13.38	13.03	13.20	12.67	12.43	12.55	11.32	11.07	11.20
	S.Em+	0.177	0.138	0.104	0.155	0.030	0.071	0.157	0.028	0.044
	CD at 5%	0.501	0.392	0.295	0.440	0.085	0.203	0.447	0.082	0.128

Conclusion

The present investigation revealed that, it is concluded that treatment combination100% RDF + 20ppm NAA + fertigation 15 days (T_{13}) significant effected on fruit retention (%), number of fruit/plant, yield kg/plant, TSS, total sugar, and reducing sugar than all other treatment combination. The treatment combination 75% RDF + 0ppm NAA + fertigation 30 days (T_4) lowest significant effected on fruit retention (%), number of fruit/plant, yield kg/plant, TSS, total sugar, and reducing sugar than all other treatment combination. The application of NAA and fertilizer of pomegranate significant effected increasing production and as well as quality of fruits.

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