



Response of nutrient supplementation through INM on yield and quality parameters of pomegranate (*Punica granatum*)

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ABSTRACT

A study was carried out during 2020–21 and 2021–22 at the research farm of Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana to investigate efficacy of different fertilizers on yield, yield attributing characters and biochemical parameter on pomegranate (*Punica granatum* L.) cv. Bhagwa. Different doses of RDF 50%, 75%, 100% FYM, biofertilizers were evaluated against control by following randomized complete block design, 22 treatments with 3 replications. The results revealed that yield parameters, viz. fruit weight (260.83 g), aril weight (168.00 g), rind weight (92.83g), rind thickness (3.63 mm), fruit length (6.64 cm) and fruit diameter width (4.82 cm), number of fruits per tree (105.61), yield (27.55 kg/tree), fruit firmness (28.76 lb/inch²), fruit cracking (26.17%), fruit set (42.30%), fruit retention (76.19%), fruit drop (23.81%); and biochemical parameters, viz. juice content (35.23%), TSS (14.15 °Brix), acidity (0.82%) and TSS acid ratio (17.37), total sugar (12.06%), reducing sugar (9.86%), non-reducing sugar (2.31%), sugar: acid ratio (41.00) ascorbic acid (16.79 mg/100 g) and anthocyanin content (4.94 mg/100 g) were significantly affected by different organic amendments and biofertilizers treatment against control. Treatment T₂₁-100% RDF + FYM + *Azotobacter* + PSB proved most effective in enhancing yield attributing characters and biochemical parameters of pomegranate. This treatment gave best result by increasing the nutritional status of the plant through the beneficial effects of different fertilizers.

Keywords: Biofertilizers, Biochemical parameters, Fruits, Organic treatments, Pomegranate, RDF

Pomegranate (*Punica granatum* L.) is native of Iran and in terms of production, India is the world's largest producer. The total area under pomegranate in India is 2.88 lakh hectares, and the total production is 32.71 lakh tonnes with a productivity of 11.40 tonnes per hectare (Anonymous 2021). Pomegranate is mainly consumed as a fresh fruit and also used in form of jams, juices, wines, vinegars and jellies (Sheikh and Manjula 2012, Gumienna *et al.* 2016). In addition to influencing nutrient needs and fruit quality, chemical fertilizer also has a substantial impact on production and plant growth. Therefore, adopting an integrated nutrient management (INM) method is critical for maintaining soil health and producing a higher yield of quality fruits. It is a traditional approach in which we first determine what exactly is required by plants for optimum level of production, in what different forms at what different timings in the best possible method and how best these

forms can be integrated to achieve highest productivity levels with efficiency at economically acceptable limits in an environmentally friendly manner. Adopting strategies such as applying organic manures and using biofertilizers in addition to inorganic fertilizers can help accomplish integrated nutrient management (Muhammad *et al.* 2000). To restore and maintain fruit output as well as help prevent emergent micronutrient shortages, balanced fertilizers must be added to the soil at the proper time, source, quantity and pattern (Tanari *et al.* 2019, Gajbhiye *et al.* 2020). Nitrogen (N) is one of the elements required by pomegranate trees, not only for healthy tree growth and maximum yield but also to improve the quality of fruits (Nasser 2018, Khalaj and Noroozisharaf 2020). INM is a dynamic concept of nutrient management is looked upon the economic yield in terms of fruit yield coupled with quality on one hand, and soil physico-chemical and microbiological health on other hand as a marker of resistance against the nutrient mining that arises because of failure to strike a balance between annual nutrient demand versus quantum of nutrients applied (Srivastava and Singh 2008). Therefore, the present experiment was conducted to investigate the efficacy of different fertilizers on yield, yield attributing characters and biochemical characters on pomegranate.

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MATERIALS AND METHODS

Present study was carried out on 66 trees of Bhagwa (6 year-old) planted at a spacing of 5 m × 5 m at the Experimental Orchard of Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana during 2020–21 and 2021–22. The experiment consisted of 22 treatments, viz. T₁ (RDF 50%); T₂ (RDF 50% + FYM 30); T₃ (RDF 50% + *Azotobacter*); T₄ (RDF 50% + FYM + *Azotobacter*); T₅ (RDF 50% + PSB); T₆ (RDF 50% + PSB + *Azotobacter*); T₇ (RDF 50% + FYM + *Azotobacter* + PSB); T₈ (RDF 75%); T₉ (RDF 75% + FYM); T₁₀ (RDF 75% + *Azotobacter*); T₁₁ (RDF 75% + FYM + *Azotobacter*); T₁₂ (RDF 75% + PSB); T₁₃ (RDF 75% + PSB + *Azotobacter*); T₁₄ (RDF 75% + FYM + *Azotobacter* + PSB); T₁₅ (RDF); T₁₆ (RDF + FYM); T₁₇ (RDF + *Azotobacter*); T₁₈ (RDF + FYM + *Azotobacter*); T₁₉ (RDF + PSB); T₂₀ (RDF + PSB + *Azotobacter*); T₂₁ (RDF + FYM + *Azotobacter* + PSB); T₂₂ (Control) in a randomized complete block design. There were 3 replications in each experiment with one fruit tree per replication. Top pan electronic balance was used to determine the fruit weight, aril weight, rind weight and expressed in gram. With the help of digital vernier caliper rind thickness, fruit length, fruit diameter (cm) were measured. A total number of fruits per plant were recorded by counting the harvested fruits in different pickings in each replication under each treatment. To calculate the fruit yield per tree total number of fruits per tree was multiplied with the average fruit weight and was expressed in kilogram (kg) per tree. Fruit firmness was measured with the help of penetrometer and their average value was calculated and expressed in lb/inch². Fruit cracking percentage was calculated by counting the cracked fruits and divided by total number of fruits and multiplied by 100. The calculation of fruit set involved counting the number of fruit set and dividing it by the total number of flowers, then multiplying the result by 100. Similarly, the calculation of fruit retention percentage required counting the number of fruit at harvest and dividing it by the initial number of fruit set, then multiplying the result by 100. Fruit drop percentage was calculated by counting the number of dropped fruit and divided by total number of fruit set and then divided by 100. Juice was extracted from arils by using manual juice extractor and expressed in percent. TSS of pomegranate fruit samples from different treatments was determined by the hand refractometer and the values were expressed in °Brix (Ranganna 1986). The method suggested by AOAC (2000) was followed for the estimation of titratable acidity. The method given by Hulme and Narain (1931) was used for the estimation of sugars. The Sugar: Acid ratio was calculated by dividing total sugars with the acidity. The ascorbic acid was estimated by using the procedure given in AOAC (2000). The anthocyanin content was estimated by using the procedure given by Ranganna (1997).

RESULTS AND DISCUSSION

Results showed that the application of an organic fertilizer in conjunction with both an inorganic fertilizer

and biofertilizers had a significant impact on yield and yield attributes characters of pomegranate (Table 1). T₂₁ proved most effective in enhancing number of fruits (105.61), followed by T₁₄ (103.61). Lowest number of fruits (83.70) was recorded in T₂₂. T₂₁ also proved most effective in increasing fruit weight (260.83 g), aril weight (168.00 g), maximum fruit length (6.64 cm) and fruit diameter width (4.82 cm). Minimum fruit weight (226.65 g), minimum aril weight (130.05 g), lowest fruit length (4.89 cm) and minimum fruit diameter (4.02 cm) was recorded in T₂₂. T₂₁ proved most effective in increasing fruit yield (27.55 kg) and T₂₁ was at par with T₁₄ (26.76 kg) and T₂₀ (26.13 kg) during the experimentation. Minimum fruit yield (18.97 kg) was observed in T₂₂. According to the rind thickness data, T₂₁ proved most effective in decreasing rind thickness (3.63 mm) was found significantly at par with T₁₄ (3.75 mm). Maximum rind thickness (4.93 mm) was observed in T₂₂. The effect was more pronounced during the second year with combination of organic and inorganic with biofertilizers. Plant metabolism is accelerated by the nutrient combinations. The presence of nitrogen positively influenced the vegetative growth of the plant, which produced more food material and when translocated into fruit bearing areas, enhanced the weight and size of the fruits. Potassium regulates water relations and phosphorus plays a vital role in carbohydrate and protein synthesis and photosynthesis. The application of FYM has been shown to enhance the dispersion of microorganisms and the capacity of soil to retain moisture. This leads to heightened enzymatic activities, specifically in phosphatase and urease, which ultimately enhances growth parameters and is reflected in augmented fruit weight and other physical characteristics. Baviskar *et al.* (2011) also reported similar results in sapota and Agnihotri *et al.* (2013) in guava. The application of biofertilizers has been shown to promote superior growth and the accumulation of optimal dry matter through the induction of growth hormones. These hormones serve to stimulate cell division and elongation, activate the photosynthetic process, enhance the translocation of crucial water and nutrients, and facilitate the growth and development of roots. Additionally, energy transformation is stimulated, which ultimately leads to an increase in fruit weight, firmness and other important physical characteristics. The present findings are in accordance with the results reported by Dutta *et al.* (2010) in litchi.

Different organic amendments and biofertilizers treatment significantly affected fruit firmness, fruit cracking, fruit set, fruit drop, fruit retention. T₂₁ proved most effective in increasing fruit firmness (28.76 lb/inch²) (Table 2) followed by T₁₄ (28.17 lb/inch²) and T₂₀ (27.55 lb/inch²). Minimum fruit firmness (21.90 lb/inch²) was observed in T₂₂. T₂₁ proved to be the most effective in decreasing fruit cracking (26.17%) followed by T₁₄ (26.95%). Maximum fruit cracking (34.22%) was observed in T₂₂.

T₂₁ was most effective in increasing anthocyanin (4.94 mg/100 g) and ascorbic acid content (16.79 mg/100 g). Minimum anthocyanin (2.52 mg/100 g) and ascorbic acid content (14.25 mg/100 g) was observed in T₂₂. Whereas,

Table 1 Effect of organic, inorganic and biofertilizers on number of fruit/trees, fruit weight, yield, aril, rind weight, rind thickness, fruit length and diameter of pomegranate

Treatment	Number of fruit/trees	Fruit weight (g)	Fruit yield (kg/tree)	Aril weight (g)	Rind weight (g)	Fruit length (cm)	Fruit diameter (cm)	Rind thickness (mm)
T ₁	85.28	227.68	19.42	131.19	96.49	4.95	4.05	4.82
T ₂	86.27	231.54	19.98	135.28	96.26	5.01	4.13	4.79
T ₃	86.98	229.25	19.94	132.95	96.30	4.98	4.09	4.70
T ₄	87.63	233.10	20.43	136.88	96.22	5.06	4.17	4.63
T ₅	90.00	236.08	21.25	140.03	96.06	5.23	4.23	4.42
T ₆	97.88	246.51	24.13	151.15	95.36	5.85	4.45	3.90
T ₇	97.50	248.01	24.18	153.21	94.80	5.96	4.50	3.89
T ₈	89.27	234.94	20.97	138.81	96.13	5.11	4.20	4.52
T ₉	90.77	237.28	21.54	141.29	95.99	5.33	4.26	4.30
T ₁₀	92.50	238.86	22.09	142.97	95.90	5.40	4.30	4.21
T ₁₁	93.65	240.54	22.52	144.71	95.84	5.46	4.34	4.14
T ₁₂	98.50	250.19	24.65	156.33	93.86	6.15	4.58	3.84
T ₁₃	100.19	252.02	25.25	158.45	93.57	6.21	4.61	3.83
T ₁₄	103.61	258.31	26.76	165.08	93.24	6.52	4.79	3.75
T ₁₅	94.00	242.37	22.78	146.65	95.72	5.55	4.36	4.06
T ₁₆	95.32	243.99	23.26	148.40	95.59	5.64	4.39	4.00
T ₁₇	96.00	245.60	23.58	150.13	95.47	5.75	4.42	3.96
T ₁₈	98.66	248.77	24.54	154.44	94.34	6.05	4.54	3.87
T ₁₉	100.55	253.77	25.52	160.33	93.45	6.34	4.64	3.81
T ₂₀	102.22	255.60	26.13	162.21	93.40	6.45	4.68	3.78
T ₂₁	105.61	260.83	27.55	168.00	92.83	6.64	4.82	3.63
T ₂₂	83.70	226.65	18.97	130.05	96.60	4.89	4.02	4.93
CD (P=0.05%)	2.79	15.15	1.45	11.47	NS	0.43	0.33	0.13

Treatment details are given under Materials and Methods.

treatment T₂₁ was found significantly superior to other treatments. Treatments T₁₄ was found significantly at par to T₂₁. Different integrated nutrient management treatments significantly impacted fruit set, fruit drop, fruit retention. T₂₁ proved most effective in enhancing fruit set (42.30%), fruit retention (76.19%) and was at par with treatment T₁₄. Lowest fruit set (31.67%), fruit retention (61.67%) was recorded in treatment T₂₂.

Results showed that fruit biochemical parameters were significantly improved by application of organic, inorganic and biofertilizers in different combination (Table 3). T₂₁ proved most effective in enhancing juice content (35.23%). Minimum juice content (27.55%) was observed in T₂₂. T₂₁ was also joined most effective in enhancing total soluble solids (14.15°Brix) and was found significantly at par with T₂₁ treatment T₁₁ to T₂₀ (13.99°Brix). Minimum total soluble solids (12.46°Brix) were observed in T₂₂ and TSS: acid ratio. However, T₂₁ proved most effective in enhancing TSS: acid ratio (117.37). Lowest TSS: acid ratio (13.15) was observed in T₂₂. Data revealed significant effect of different treatments on reducing sugars, non-reducing sugars and total sugars. However, T₂₁ proved most effective in enhancing reducing

sugars (9.86%), non-reducing sugars (2.31%), total sugars (12.06%) and was found significantly at par to T₁₄. Minimum reducing sugars (8.83%), non-reducing sugars (1.80%), total sugars (10.63%) were observed in T₂₂. The comprehensive utilization of organic manures, chemical fertilizers, and biofertilizers resulted in a notable augmentation in crop productivity in addition to an enhancement of fruit quality. This integrated approach significantly elevated the diverse physicochemical indicators, such as total soluble solids, acidity, TSS: Acid ratio, total, reducing and non-reducing sugars, ascorbic acid, and anthocyanin. Maximum TSS, sugars content, ascorbic acid and anthocyanin and minimum acidity were estimated in T₂₁. Improvement in the quality of fruits might be due to the proper absorption and desired quantity of nutrients made available to plants with the use of chemical fertilizers. These results are in accordance with the findings of Nandi *et al.* (2013) in pomegranate. The increase in physiochemical characteristics of pomegranate fruit by the combined application of bio organic and inorganic nutrient sources might be due to cumulative effect of increased population of bacteria, biological N-fixation which increased uptake of nutrients like P, Zn, Cu, Mn, Fe

Table 2 Effect of organic, inorganic and biofertilizers on fruit firmness, fruit cracking, fruit set, drop, retention, ascorbic acid and anthocyanin content of pomegranate

Treatment	Fruit firmness (lb/inch ²)	Fruit cracking (%)	Fruit set (%)	Fruit drop (%)	Fruit retention (%)	Ascorbic acid (mg/100 g)	Anthocyanin (mg/100 g)
T ₁	22.28	33.63	31.89	33.57	66.43	14.31	2.58
T ₂	22.80	32.75	32.83	34.12	65.88	14.38	2.80
T ₃	22.55	33.33	32.41	34.60	65.40	14.44	2.66
T ₄	23.06	32.27	32.87	35.59	64.41	14.50	2.92
T ₅	23.60	30.81	33.21	32.50	67.50	14.69	3.12
T ₆	25.69	29.29	37.02	28.13	71.87	15.39	3.88
T ₇	25.97	29.04	37.67	28.73	71.27	15.50	4.02
T ₈	23.36	31.73	33.15	33.76	66.24	14.59	2.99
T ₉	23.91	30.66	33.61	32.68	67.33	14.77	3.21
T ₁₀	24.23	30.59	34.39	30.47	69.53	14.87	3.33
T ₁₁	24.54	30.48	34.95	29.52	70.48	14.97	3.41
T ₁₂	26.50	28.64	38.10	28.89	71.11	15.78	4.27
T ₁₃	26.82	28.14	39.23	29.05	70.95	15.94	4.40
T ₁₄	28.17	26.95	41.37	26.76	73.24	16.51	4.77
T ₁₅	24.77	30.30	35.59	30.54	69.46	15.07	3.51
T ₁₆	25.07	29.93	36.33	30.34	69.66	15.17	3.61
T ₁₇	25.40	29.83	36.86	29.81	70.19	15.27	3.75
T ₁₈	26.22	28.86	37.79	28.02	71.98	15.63	4.17
T ₁₉	27.11	27.89	39.34	28.64	71.36	16.14	4.52
T ₂₀	27.55	27.46	40.15	27.26	72.74	16.32	4.66
T ₂₁	28.76	26.17	42.30	23.81	76.19	16.79	4.94
T ₂₂	21.90	34.22	31.67	38.33	61.67	14.25	2.52
CD (P=0.05%)	1.94	0.95	1.06	0.89	1.89	0.42	0.10

Treatment details are given under Materials and Methods.

etc., and production of growth regulators by *Trichoderma* in the root zone (Sharma *et al.* 2005). Potassium serves as a catalyst in the creation of more intricate substances and in the hastening of enzyme activity. The carbohydrates and coenzymes are advantageous in ameliorating fruit quality, while nitrogen heightens the absorption of potassium and phosphorus. The chain reactions inherent in these components could plausibly account for the advancement in fruit quality. Similar findings have been documented by Kumar *et al.* (2009) in guava. The microorganisms present in biofertilizers have led to the enhancement of fruit quality owing to the expeditious mineralization and transformation of plant nutrients in soil (Chandra *et al.* 2016). The improvement in fruit quality can be ascribed to the continuous provision of nutrients, higher concentration of soil enzymes and microorganisms, as well as the utilization of more friable and porous soils through the application of FYM. This phenomenon can be attributed to the better vegetative growth of the fertilized plants, which results in increased quantities of photosynthates, such as starch and carbohydrates, and their transportation to the fruits. As a consequence, various physico-chemical parameters of the

fruit were improved, leading to an overall enhancement in fruit quality. These findings are corroborated by the works of Dhaval and Naik (2010) in sapota and Sau *et al.* (2017) in guava. Vitamin C and pectin content increased due to fixation of atmospheric nitrogen, increased availability of phosphorus and secretion of growth promoting substances by accelerating the physiological process like carbohydrate synthesis by the microbial inoculants (Tripathi *et al.* 2014). Results are in close conformity with that of Rubee *et al.* (2011) in guava and Yadav *et al.* (2011) in mango.

It can be concluded that applying of different fertilization combinations improved the quality of pomegranate fruit cv. Bhagwa. The integrated application of RDF + FYM + azotobacter + PSB was more conducive to increase fruit weight, aril weight, fruit length, fruit diameter, number of fruit per tree, yield, total soluble solids, fruit firmness, fruit set, fruit retention, ascorbic acid, anthocyanin, sugar content, juice percent, sugar acid ratio and to decrease titratable acidity, fruit cracking, rind weight, rind thickness, fruit drop. Based on the findings, pomegranate growers could be advised to use an organic combination of RDF 100% + FYM 30 kg/plant

Table 3 Effect of organic, inorganic and biofertilizers on juice per cent, TSS, acidity, TSS: acid ratio, reducing, non-reducing, total sugars, sugars: acid ratio of pomegranate

Treatment	Juice (%)	Total soluble solids (°Brix)	Acidity (%)	TSS: acid ratio	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Sugars: acid ratio
T ₁	27.89	12.49	0.92	13.66	8.88	1.80	10.68	26.19
T ₂	28.43	12.68	0.91	14.01	8.93	1.80	10.73	26.70
T ₃	28.13	12.58	0.92	13.85	8.98	1.80	10.77	27.08
T ₄	28.87	12.74	0.91	14.13	9.01	1.82	10.83	27.63
T ₅	29.47	12.92	0.90	14.43	9.10	1.83	10.93	28.18
T ₆	32.00	13.49	0.87	15.71	9.44	1.98	11.42	32.33
T ₇	32.56	13.59	0.86	15.92	9.48	2.03	11.50	33.51
T ₈	29.23	12.81	0.90	14.26	9.05	1.83	10.88	28.05
T ₉	29.93	12.98	0.90	14.53	9.16	1.84	10.99	28.79
T ₁₀	30.17	13.06	0.89	14.86	9.20	1.85	11.05	29.26
T ₁₁	30.48	13.13	0.88	15.09	9.24	1.88	11.12	29.92
T ₁₂	33.33	13.78	0.85	16.27	9.55	2.10	11.65	34.38
T ₁₃	33.67	13.85	0.84	16.53	9.59	2.14	11.73	35.66
T ₁₄	34.78	14.06	0.83	17.09	9.69	2.25	11.94	37.98
T ₁₅	30.78	13.21	0.88	15.16	9.30	1.89	11.19	30.79
T ₁₆	31.26	13.32	0.87	15.43	9.35	1.92	11.26	31.50
T ₁₇	32.09	13.40	0.87	15.52	9.38	1.95	11.34	32.09
T ₁₈	32.99	13.67	0.86	16.10	9.51	2.07	11.58	33.74
T ₁₉	34.08	13.92	0.83	16.85	9.61	2.20	11.80	37.02
T ₂₀	34.44	13.99	0.83	16.99	9.65	2.22	11.87	37.75
T ₂₁	35.23	14.15	0.82	17.37	9.86	2.31	12.06	41.00
T ₂₂	27.55	12.46	0.95	13.15	8.83	1.80	10.63	25.10
CD (P=0.05%)	2.63	1.05	0.07	1.70	0.28	0.07	0.35	1.01

Treatment details are given under Materials and Methods.

+ azotobacter (150 ml/litre/plant) + PSB (150 ml/litre/plant) to improve the yield and quality characteristics of pomegranate fruits, as well as to improve the nutritional status and microbial population of the soil which aids in the growth, yield and quality of pomegranates.

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