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Integrated nutrient management enhances yield and fruit quality in pomegranate (*Punica granatum* L.) cv. Bhagwa

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Abstract

The field experiment was conducted to study the effect of integrated nutrient management on yield and quality of pomegranate (*Punica granatum* L.) cv. Bhagwa during 2023-24. The experiment was laid out in randomized block design with eleven treatments and three replications. The results revealed that among the different treatments used, the application 75% RDF + Poultry manure @ 10 kg tree⁻¹ + Bio NPK consortium @ 10 ml tree⁻¹ + Bio-stimulants (foliar spray of seaweed extract @ 0.3% and humic acid @ 0.2%) + Micronutrient foliar spray @ 1 % significantly increased the quality attributes of pomegranate. This treatment improved fruit yield and quality in terms of maximum number of fruits tree⁻¹ (66.94), fruit weight (217.18), yield tree⁻¹ (13.30 kg), yield ha⁻¹ (22.18 t), TSS (15.02), TSS: acid ratio (34.93). The findings revealed that integrated nutrient management through optimized use of RDF, poultry manure, Bio NPK consortium, seaweed extract, humic acid and micronutrient mixture enhances yield and quality of pomegranate.

Keywords: Pomegranate, Bhagwa, *Ambe bahar*, poultry manure, organic, biofertilizer, seaweed extract and humic acid

Introduction

Pomegranate (*Punica granatum* L.) is one of the important fruit crops of tropical and sub-tropical regions of the world. The fruit can withstand hardy climatic condition and able to produce cool and refreshing sweet arils with high medicinal values (Holland and Bar-Ya'akov, 2018) [11]. In India, pomegranate is commercially cultivated in Maharashtra, Andhra Pradesh, Uttar Pradesh, Gujarat, Rajasthan, Tamil Nadu and parts of Karnataka, where high quality fruits are produced due to prevailing dry and hot climatic conditions (Marathe *et al.*, 2022) [18]. The fruit is highly valued for its attractive appearance, unique flavour, extended shelf life and its abundance of bioactive compounds such as anthocyanins, tannins and phenolics. These phytochemicals are well known for their antioxidant properties and their role in promoting human health (Stiletto and Trestini, 2021) [29]. Over the past decade, the acreage and output of pomegranate in India have shown a consistent upward trend (Madrewar *et al.*, 2025) [16]. Although pomegranate is well-suited to diverse agro-climatic conditions, it is highly dependent on adequate nutrient supply and soil fertility for maintaining yield and fruit quality. A sustainable approach should be adopted for higher production of quality fruits. Adopting strategies such as applying organic manures and using biofertilizers in addition to inorganic fertilizers can help accomplish integrated nutrient management (Singh *et al.*, 2024) [27]. To restore and maintain fruit output as well as preventing emergent micronutrient deficiencies, balanced fertilizers with appropriate source, rate, timing and method of application is crucial (Tanari *et al.* 2019, Gajbhiye *et al.* 2020) [30, 7]. Therefore, the present experiment was conducted to investigate the efficiency of integrated nutrient management on yield and quality attributing characters in pomegranate cv. Bhagwa.

Materials and Methods

The present research was carried out during the year 2023-24 on the farmers' field, Tiruchengode, Namakkal, Tamil Nadu, India. In present investigation, 6-years-old pomegranate orchard of a 'Bhagwa' planted at distance of 3m×2m was selected for the study.

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The trial was laid out in a Randomized Block Design (RBD) with eleven treatments and three replications. The experiment consisted of the following treatments: T₁.100% RDF (Control); T₂.75% RDF + Poultry manure @ 10 kg tree⁻¹; T₃.50% RDF + Poultry manure @ 20 kg tree⁻¹; T₄.75% RDF + Poultry manure @ 10 kg tree⁻¹ + Bio NPK consortium @ 10 ml tree⁻¹; T₅.50% RDF + Poultry manure @ 20 kg tree⁻¹ + Bio NPK consortium @ 10 ml tree⁻¹; T₆.75% RDF + Poultry manure @ 10 kg tree⁻¹ + Seaweed extract @ 0.3% and Humic acid @ 0.2%; T₇.50% RDF + Poultry manure @ 20 kg tree⁻¹ + Seaweed extract @ 0.3% and Humic acid @ 0.2%; T₈.75% RDF + Poultry manure @ 10 kg tree⁻¹ + Bio NPK consortium @ 10 ml tree⁻¹ + Seaweed extract @ 0.3% and Humic acid @ 0.2%; T₉.50% RDF + Poultry manure @ 20kg tree⁻¹ + Bio NPK consortium @ 10ml tree⁻¹ + Seaweed extract @ 0.3% and Humic acid @ 0.2%; T₁₀.75% RDF + Poultry manure @ 10 kg tree⁻¹ + Bio NPK consortium @ 10ml tree⁻¹ + Seaweed extract @ 0.3% and Humic acid @ 0.2%+Micronutrient mix @ 1%; T₁₁.50% RDF + Poultry manure @ 20 kg tree⁻¹ + Bio NPK consortium @ 10ml tree⁻¹ + Seaweed extract @ 0.3% and Humic acid @ 0.2% + Micronutrient mix @ 1%. The recommended dose of fertilizers (RDF) for pomegranate trees older than five years (625:250:250 g N: P₂O₅: K₂O plant⁻¹ year⁻¹) was adopted and applied in split doses based on the recommendations of the TNAU, Coimbatore. Poultry manure was incorporated uniformly into the soil around the active root zone according to the treatments. A Liquid Bio-NPK Consortium containing Rhizobium, Azotobacter, Phosphobacteria, Potash Solubilizing Bacteria (Total viable cell count: 1.5×10⁸ CFU/ml) was applied as soil drenching at 10ml tree⁻¹. Biostimulants comprising seaweed extract (0.3%) and humic acid (0.2%) were applied as foliar sprays. A micronutrient mixture (Grade IV) containing Fe(4.0%), Mn(1.0%), Zn(6.0%), Cu(0.5%) and B(0.5%) was applied as a 1% foliar spray. The yield and quality parameters were observed. The data on parameters were tabulated and subjected to statistical analysis using method of analysis of variance (ANOVA) for Randomized Block Design (RBD).

Results and Discussion

Integrated nutrient management treatments significantly influenced yield and fruit quality parameters of pomegranate cv. Bhagwa (Table 1). Among the treatments, T₁₀ recorded the highest number of fruits per plant (66.94), maximum fruit weight (217.18 g), highest yield per tree (13.30 kg) and yield per hectare (22.18 t ha⁻¹). This was followed by T₈, which registered 65.27 fruits per plant, fruit weight of 214.38 g, yield per tree of 12.79 kg and yield per hectare of 21.32 t ha⁻¹. In contrast, the control treatment T₁ recorded the lowest number of fruits per plant (49.28), fruit weight (187.26 g), yield per tree (8.41 kg) and yield per hectare (14.03 t ha⁻¹).

The significant improvement in number of fruits per tree, fruit weight and yield per tree under integrated nutrient management treatments may be attributed to the synergistic contribution of organic, biological and micronutrient inputs in enhancing nutrient availability and physiological efficiency. Poultry manure, being a rich source of macro and micronutrients, improves soil structure, organic carbon status and microbial activity, thereby ensuring sustained nutrient release throughout the crop growth period. Enhanced nutrient supply, particularly nitrogen and phosphorus, promotes flower retention, fruit set and

subsequent fruit development (Choudhary *et al.*, 2022) [5]. The application of biofertilizers through liquid Bio-NPK consortium likely improved nitrogen fixation, phosphorus solubilization and potassium mobilization in the rhizosphere, leading to improved nutrient uptake efficiency (Gehlot *et al.*, 2024) [8]. Increased microbial activity also stimulates root proliferation and enhances the absorption of water and nutrients, which directly influences fruit number and fruit weight. Similar improvements in yield attributes due to integrated application of organic manures and biofertilizers have been reported in pomegranate (Kurer *et al.*, 2017) [15] and guava (Chandra *et al.*, 2016; Sourabh *et al.*, 2018) [4, 28]. Foliar application of seaweed extract and humic acid may have further enhanced yield parameters by stimulating metabolic activities and improving photosynthetic efficiency (Sajjadullah *et al.*, 2022) [25]. Seaweed extracts contain bioactive compounds such as cytokinins and auxins that enhance fruit set and reduce flower drop, while humic acid improves nutrient translocation and assimilate partitioning towards developing fruits (Gonçalves *et al.*, 2025) [9]. Enhanced carbohydrate synthesis and effective source-sink relationship under bio-stimulant application may have contributed to increased single fruit weight and overall yield (Maity *et al.*, 2024) [17]. Micronutrients (Fe, Zn, Mn, Cu, and B) are essential for enzymatic reactions, pollen viability and fertilization processes. Adequate boron and zinc supply are known to enhance fruit set and fruit development, thereby increasing fruit number and yield (Yadav *et al.*, 2022) [31]. Improved yield performance under integrated nutrient management has also been documented in fruit crops such as mango (Kumari *et al.*, 2020) [14], citrus (Bhattacharjee *et al.*, 2024) [3] and pomegranate (Meena *et al.*, 2018) [19] under balanced nutrient application. Thus, the combined application of RDF, poultry manure and biofertilizers along with foliar bio-stimulants and micronutrients ensured improved nutrient availability, enhanced physiological activity and efficient assimilate partitioning, resulting in superior yield attributes in pomegranate.

Quality parameters

Fruit quality parameters also exhibited significant variation among treatments. The highest total soluble solids (TSS) content was recorded in T₁₀ (15.02 °Brix), followed by T₈ (14.87 °Brix), whereas the control treatment recorded the lowest TSS (13.64 °Brix). Titratable acidity was lowest in T₁₀ (0.43) and highest in T₁ (0.51). Consequently, the TSS: acid ratio was maximum in T₁₀ (34.93), followed by T₈ (33.80), while the control registered the lowest ratio (26.75). Treatments involving integrated application of inorganic fertilizers, organic manure, biofertilizers, bio-stimulants, and micronutrients consistently outperformed the control in terms of yield and fruit quality attributes.

Integrated nutrient management significantly influenced total soluble solids (TSS), titratable acidity, and TSS: acid ratio, indicating improvement in fruit quality. The enhancement in TSS under integrated treatments may be associated with improved carbohydrate synthesis and translocation resulting from balanced nutrient availability (Abdel-Sattar *et al.*, 2023) [1]. Poultry manure contributes to sustained nutrient supply and improved soil microbial activity, which enhances nutrient uptake and metabolic processes involved in sugar accumulation (Sharma *et al.*, 2022) [26]. Biofertilizers further improve nutrient use

efficiency and stimulate root activity, facilitating better absorption of nutrients required for sugar synthesis and organic acid metabolism. Increased microbial activity in the rhizosphere also promotes plant growth regulator production, indirectly influencing fruit quality attributes (Mir *et al.*, 2015) [20]. Foliar application of seaweed extract may have contributed to higher TSS due to enhanced photosynthetic rate and improved translocation of assimilates to fruits (Mousavi *et al.*, 2024) [22]. Seaweed-derived cytokinins and growth-promoting substances have been reported to improve fruit quality parameters in various fruit crops (Ali *et al.*, 2021) [2]. Similarly, humic acid improves nutrient chelation and uptake efficiency, resulting in enhanced sugar accumulation and improved TSS (Rashedy *et al.*, 2022) [24]. The reduction in titratable acidity and improvement in TSS: acid ratio under integrated

treatments may be attributed to enhanced metabolic conversion of organic acids into sugars during fruit maturation under balanced nutrition (Moradinezhad, and Ranjbar, 2024) [21]. Micronutrients play a crucial role in enzyme activation and carbohydrate metabolism, thereby influencing sugar-acid balance and improving overall fruit taste and market quality (Hussian *et al.*, 2024) [12]. Comparable improvements in fruit quality due to integrated nutrient management have been reported in pomegranate (Gajbhiye *et al.*, 2022) [6], mango (Harsh *et al.*, 2025) [10], citrus (Kumar *et al.*, 2017) [13] and guava (Preet *et al.*, 2021) [23] under combined application of organic manures and biofertilizers. The enhancement in TSS and TSS: acid ratio observed in the present study indicates improved biochemical composition and market acceptability of fruits under integrated nutrient application.

Table 1: Effect of different integrated nutrient management treatments on yield and quality of pomegranate cv. Bhagwa

Treatments	No. of fruits plant ⁻¹	Fruit weight(g)	Yield tree ⁻¹ (kg)	Yield ha ⁻¹ (tonnes)	TSS (°Brix)	Acidity	TSS: Acid Ratio
T ₁	49.28	187.26	8.41	14.03	13.64	0.51	26.75
T ₂	53.46	195.64	9.49	15.82	13.89	0.48	28.94
T ₃	51.73	192.92	9.06	15.10	13.76	0.49	28.08
T ₄	61.92	208.79	11.79	19.65	14.58	0.45	32.40
T ₅	56.88	200.54	10.38	17.30	14.14	0.47	30.09
T ₆	60.25	206.02	11.31	18.86	14.44	0.45	32.09
T ₇	55.19	197.72	9.91	16.53	14.01	0.47	29.81
T ₈	65.27	214.38	12.79	21.32	14.87	0.44	33.80
T ₉	58.57	203.38	10.85	18.09	14.28	0.46	31.04
T ₁₀	66.94	217.18	13.30	22.18	15.02	0.43	34.93
T ₁₁	63.51	211.55	12.28	20.47	14.71	0.44	33.43
SEd.	0.61	1.19	0.19	0.37	0.06	0.04	0.32
CD (0.05)	1.28	2.43	0.42	0.74	0.13	0.07	0.67

Conclusion

Integrated nutrient management combining inorganic and organic poultry manure, liquid Bio-NPK consortium with foliar application of seaweed extract, humic acid and micronutrient mixture significantly improved yield and fruit quality of pomegranate cv. Bhagwa. Enhanced fruit number and fruit weight reflected better assimilate partitioning and reproductive efficiency. Improvements in total soluble solids and TSS: acid ratio indicate enhanced biochemical quality under balanced soil and foliar nutrition. The results demonstrate that strategic integration of organic, biological, and micronutrient inputs can optimize nutrient use efficiency and productivity without exclusive dependence on chemical fertilizers. This approach offers a sustainable and agronomically viable nutrient management strategy for high-density pomegranate orchards under semi-arid conditions.

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