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Impact of bioenhancers and biofertilizers on growth, yield and quality of mango (*Mangifera indica* L.) cv. Amrapali

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Abstract

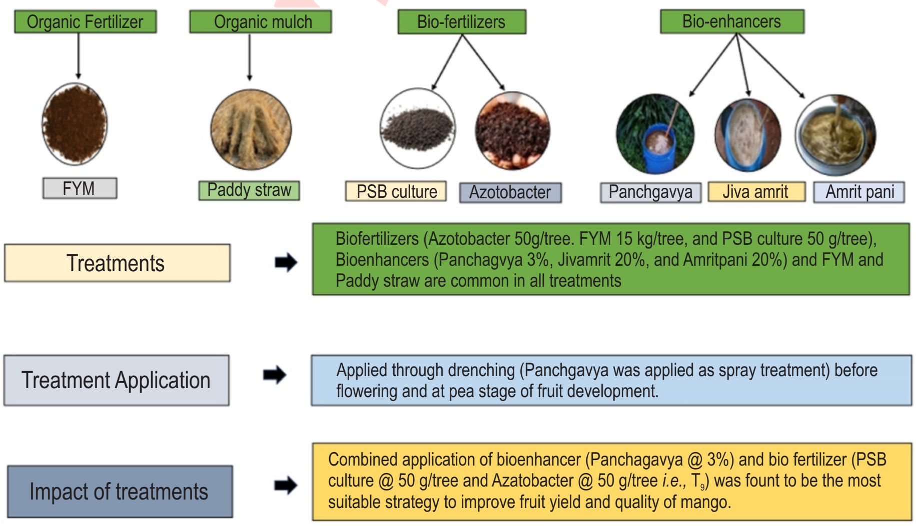
Aim: The study aimed to assess the effects of bioenhancers and biofertilizers on mango yield and fruit quality, with the goal of promoting sustainable production practices and enhancing export potential.

Methodology: Bioenhancers (Panchagavya, jivamrit, amritpani) and biofertilizers (Azotobacter, Phosphate solubilizing Bacteria (PSB), and FYM) were applied to mango trees through soil drenching, except panchagavya, which was sprayed at two stages, *i.e.,* pre-flowering and pea stage of fruit development. Treatments were evaluated for their effects on fruit weight, volume, TSS, acidity, sugars and carotenoids.

Results: Application of panchgavya at 3%, PSB at 50 g per tree, and Azotobacter at 50 g per tree significantly improved the mango fruit weight (160.8 g to 258.63 g), volume (178.76 - 263.91 g cc^{-1}), yield per tree (34.10 – 56.69 kg per tree) TSS (17.20 – 20.20 ^{0}Brix), sugars (15.02 – 21.35%), carotenoids (8.02 – 8.68 mg 100 g^{-1}), while reduced acidity (0.50 - 0.12%) compared to control, indicating enhanced yield and fruit quality through organic inputs for sustainable production of mango.

Interpretation: The combined use of bioenhancers and biofertilizers significantly improved the mango fruit yield and quality traits, indicating their potential as a sustainable alternative of chemical fertilizers to enhance productivity and fruit quality.

Key words: Bioenhancers, Biofertilizers, Fruit quality, *Mangifera indica* cv. Amrapali, Mango



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Introduction

Mango (*Mangifera indica* L.), belonging to the family Anacardiaceae, is also known as the "king of fruits". Despite its economic and nutritional importance, mango productivity and fruit quality are often constrained by declining soil fertility, imbalanced nutrient management and excessive dependence on chemical fertilizers. In recent years, the use of bio-enhancers and biofertilizers has gained considerable attention as sustainable alternatives for improving soil health, nutrient availability, microbial activity and plant growth. These eco-friendly inputs improve nutrient uptake efficiency, stimulate root growth and enhance crop productivity while maintaining environmental sustainability (Bhardwaj *et al.,* 2014). Biofertilizers such as Azotobacter, phosphate-solubilizing bacteria (PSB) and arbuscular mycorrhizal fungi (AMF) have been reported to improve nutrient availability and yield in fruit crops (Yadav *et al.,* 2017). Similarly, bio-enhancers including panchagavya, jeevamrit and vermiwash positively influence plant growth, flowering and fruit quality by enhancing beneficial microbial activity in the rhizosphere (Pathak and Ram, 2013). With a total production of 21 million tons, the average productivity of mango in India is only 8.8 tons ha^{-1}, which is quite low (Govt. of India 2025).

Therefore, research on the integrated use of bio-enhancers and biofertilizers in mango cultivation is essential for developing sustainable nutrient management practices aimed at improving productivity, fruit quality and soil health. The fruit is unique in flavour and aroma and is a rich source of nutrients and minerals (potassium, magnesium, calcium, phosphorus, iron, zinc and copper). In addition, mango is an excellent source of vitamins 'A' and 'E' and selenium, which helps to protect against heart disease and other similar disorders (Dutta, 2006). However, to increase the fruit productivity in a sustainable manner is a challenge. Although chemical fertilizers have been used to improve the production, nevertheless these are deleterious for soil health. Hence, focus is gradually shifting towards organic inputs which necessitates to work out the effects of such inputs on production and fruit quality. Existing studies often focus on conventional inputs, leaving a gap in understanding how eco-friendly alternatives can sustainably boost yield and fruit quality. Given the importance of mango to India's horticultural economy, investigation has been conducted on the role of bioenhancers and biofertilizers in improving its productivity and quality.

Present study, addresses this gap to justify the crucial role of these inputs. This may provide scientific evidence for integrating bio-based inputs for mango production to enhance growth, yield as well as market value. Bioenhancers and biofertilizers are organically produced inputs used to promote sustainable agriculture. Bioenhancers, are mixtures of beneficial microbes isolated from native natural farming products. They contain essential macro and micronutrients as well as growth hormones such as indole-3-acetic acid and gibberellins necessary for plant growth (Selvaraj *et al.,* 2003). Among these, Panchgavya is commonly applied in organic farming as a foliar spray, soil amendment, and seed treatment to stimulate growth and immunity (Vallimayil and Sekar, 2012). Biofertilizers are mixtures of microorganisms, including bacteria, fungi or cyanobacteria, that enhance plant growth, development, and soil health when applied to or soil. Notable examples include Azotobacter and Phosphate Solubilizing Bacteria (PSB) culture, which fix atmospheric nitrogen and increases phosphorus availability in plants. In recent years, the growing emphasis on sustainable and eco-friendly agriculture has prompted researchers to explore microbial solutions to improve crop productivity. Studies have demonstrated a close relationship between plants and microbial communities highlighting their reciprocal influence on each other's growth and survival (Santos *et al.,* 2019; Vejan *et al.,* 2016). Biofertilizers have been reported to improve the plant growth, yield and quality attributes in guava (Singh *et al.,* 2020), custard apple (Raut *et al.,* 2020), papaya (Chawla *et al.,* 2020) and banana (Gupta *et al.,* 2025).

Microbes present in biofertilizers can convert atmospheric nitrogen into a form usable by plants, increase phosphorus availability, improve soil aeration and water retention, and stimulate root growth and overall plant health (Ahmad *et al.,* 2018; Barnawal *et al.,* 2017). Foliar application of bioenhancers has emerged as an effective strategy to reduce chemical inputs in crops. Growth-regulating bioenhancers such as Panchagvya, Amritpani and Jivamrit have the potential to enhance the growth and development of fruit crops. Bioenhancers contain higher concentrations of macronutrients, trace elements, organic substances like amino acids, antioxidants, organic acid, and plant growth regulators like auxin, cytokinins and gibberellins, which help to enhance nutritional status, vegetative growth, quality of fruit and plants yield, (Crouch *et al.,* 1992). Significant amounts of microorganisms found in bioenhancers develop and have a boosting effect on the soil. Bioenhancers increase the biological activity in the soil and make more nutrients available for crops (Gore and Sreenivasa, 2011). With this backdrop, this study was conducted to determine the effects of biofertilizers and bioenhancers on the growth and yield of mango cv. Amrapali.

Materials and Methods

The investigation was conducted in the Research Garden, Department of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.), during 2022-23. The site is located at 25° 26´ N latitude and 79° 31´ E longitude, at an elevation of 125.90 m above mean sea level. Climatic conditions were generally dry and warm during summer (April to June), with maximum temperature reaching up to 44°C. January was the coldest month with temperature dropping $2\text{-}3^{0}C$. The experimental site received an annual rainfall of 800-850 mm, of which 70-75% downpour occurred between June to September and the remaining 25 to 30% during winters. Soil of the experimental site was sandy loam with 0.40% organic carbon, 186.81 kg ha^{-1} available nitrogen, 20.37 kg ha^{-1} available phosphorus 261.64 kg ha^{-1} available potassium, 7.2 pH and 0.45

dS m^{-1} EC, which is low to medium range of these nutrients. The experiment was conducted in the randomized block design with 10 treatments and 3 replications. Treatments were applied to 28-year-old mango trees planted at a spacing of 3 × 3 m. Farm yard manure (15 kg per tree) and organic mulch (paddy straw) was applied to all the treatments. The treatments comprised, T_1-Control, T_2-Amritpani (20-%) + Azotobacter (50 g per tree), T_3-Panchagavya (3%) + Azotobacter (50 g per tree), T_4-Jivamrit (20%) + Azotobacter (50 g per tree), T_5-Amritpani (20%) + PSB culture (50g per tree), T_6-Panchagavya (3%) + PSB culture (50g per tree), T_7-Jivamrit (20%) + PSB culture (50g per tree), T_8-Amritpani (20%) + PSB culture (50g per tree) + Azotobacter (50g per tree), T_9-Panchagavya (3%) + PSB culture (50g per tree) + Azotobacter (50g per tree) and T_{10}-Jivamrit (20%) + PSB culture (50 g per tree) + Azotobacter (50 g per tree).

Panchagavya was prepared by mixing 7 kg of fresh cow dung with 1 kg cow ghee in a wide-mouth pot and stirring clock-wise and anti-clock-wise with a wooden rod for 5 min. Mixing process was repeated morning and evening each day up to 3 days. After 3 days, 10 l of fresh cow urine and 10 l water were added, and the mixture was allowed to ferment for 15 days with daily stirring. Subsequently, 3 l cow milk, 2 l cow curd, 3 l fresh coconut water, 3 kg jaggery and 1 dozen ripe banana were added, and the mixture was stirred daily for an additional 30 days. After fermentation, the mixture was filtered through muslin cloth, and the filtrate was used as panchgavya for foliar spraying (Pathak and Ram, 2013).

Jivamrit was prepared by mixing 10 kg cow dung (Indian breed) with 5 L cow urine and 5 L water. Subsequently, 2 kg jaggery, 2 kg pulse flour and handful virgin soil from the farm's bund was added in this. The solution was thoroughly mixed and allowed to settle in the shade for 48 hr. After 48 hr, this solution was filtered through muslin cloth. Filtrate was used as Jivamrit for drenching the trees (Pathak and Ram, 2013).

Amritpani was prepared by blending 500 g honey/ jaggery with 10 kg fresh cow dung to make a creamy mixture. This was blended with 250 g cow ghee. Mixture was poured into 200 L of water in a tank and shaken thoroughly to achieve a uniform suspension. Mouth of the container was sealed with cloth. This mixture was mixed following the morning-evening clock wise and anti-clock wise rotation with wooden stick each day up to 7 days. After 7 days this mixture was filtered through muslin cloth. Filtrate was used as amritpani for drenching the trees (Pathak and Ram, 2013).

The recommended concentration of panchgavya (3%), Jivamrit (20%), and amritpani (20%) were applied twice at the flower bud differentiation and pea stage of fruit development, in combination with bio fertilizers. Ten litters of solution per tree was applied to ensure through canopy coverage using a pneumatic foot sprayer. PSB culture and Azotobacter were applied through broadcasting near the root zone area. All treatments were applied in the afternoon between 4:00 and 6:00 pm. Then paddy straw was employed as organic mulch in the root zone to cover the drenching area. For postharvest observations, 5 fruits were randomly selected and fruit length (cm), fruit width (cm) was recorded in the lab using scale and vernier calliper. Volume was measured through water displaced method and fruit weight by weighing balance. TSS was measured by Erma Hand Refractometer. Acidity was measured by titration method and reducing sugars were estimated by Folin and Wu's method as reported in Horwitz (1975), total sugars were estimated by anthrone method (Hedge and Hofreiter, 1962). Statistical analysis of the data was performed using SAS software ver. 9.1.

Results and Discussion

Growth and flowering characters such as blooming time, number of leaves per shoot and number of inflorescences per branch, revealed significant impact of bio-enhancers and bio-fertilizers in mango. The maximum number of leaves per shoot (33.99) was recorded in T_9 (Panchagavya 3% + PSB culture 50g per tree + Azotobacter 50g per tree) whereas, the minimum (21.99) was observed in T_1 (control) (Fig 1). The superior performance of T9 may be attributed to the synergistic effect of foliar and soil applied bioenhancer (panchagavya) and biofertilizer (PSB and Azotobacter). Panchagavya consistently produces large leaves and dense canopy (Somasundaram et al., 2007; Tharmaraj *et al.,* 2011) which enhances photosynthesis and yield. Bio-fertilizers application improves soil's capacity to support the plant growth, development and production through enhanced microbial population (Nayyer *et al.,* 2014; Tripathi *et al.,* 2017). Furthermore, application of bioenhancers was found to considerably increase the number leaves per shoots. Bioenhancer, *i.e.,* panchagavya is rich source of minerals, vitamins, amino acids and plant growth regulators such as gibberellins and auxins (Sreenivasa *et al.,* 2010) and abundant in beneficial microorganisms including phosphorous solubilising bacteria, *Azotobacter* and *Pseudomonas* (Singh *et al.,* 2018).

Liquid organic products such as panchagavya and biofertilizers positively affect vegetative growth, flowering and mango yield (Chaudhary *et al.,* 2010). The minimum duration of flowering (15.66 days) was recorded in treatment T_9 (Fig. 2). However, the maximum duration of flowering (23.66 days) was observed in T_1. This could be because panchagavya, is a rich source of macro nutrients like nitrogen, phosphorus and potassium as well as micronutrients such as boron, zinc and manganese. Higher availability of nutrients facilitates faster growth and development of plants (Rakesh *et al.,* 2017). Moreover, increased use of biofertilizers enhances nitrogen fixation and increases nutrients in the soil (Binepal *et al.,* 2013). Biofertilizers enhance soil stability and nutrient recycling, improve biological control and stimulate mycorrhizal symbiosis (Sivakumar *et al.,* 2001).

Furthermore, application of bio-fertilizers increases soil fertility and productivity per unit area, since they gradually release additional nutrients into the soil. Bio-fertilizers contribute macronutrients, micronutrients, vitamins, essential amino acids,

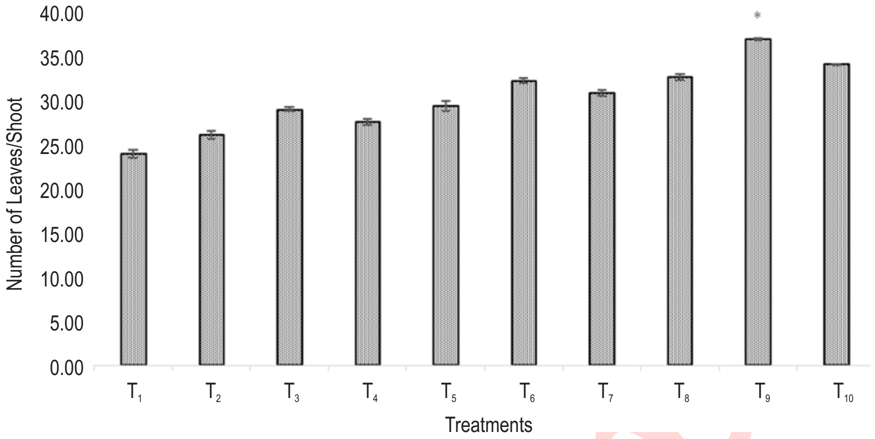

Fig. 1: Effect of bio-enhancers and bio-fertilizers on the number of new leaves per shoot. *Values in the figure are mean ±S.E.

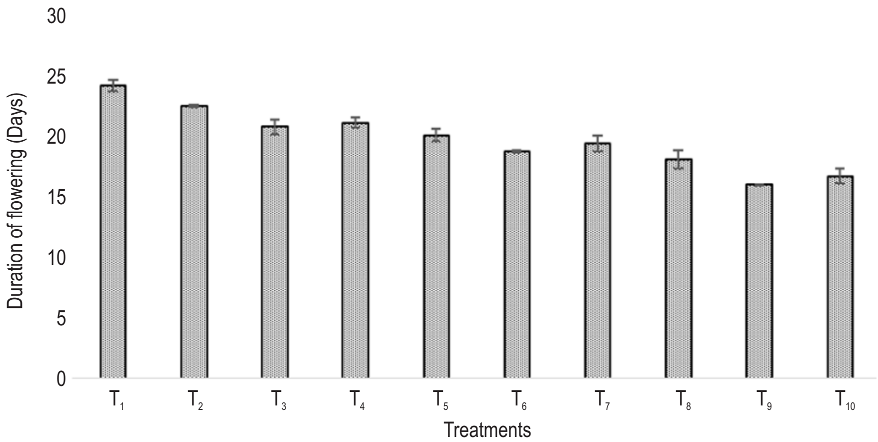

Fig. 2: Effect of bio-enhancers and bio-fertilizers on the duration of flowering. *Values in the figure are mean ±S.E.

growth promoting substances and beneficial microorganisms required for enhanced growth and flowering (Tripathi *et al.,* 2017; Mishra *et al.,* 2015; Tripathi *et al.,* 2016). The maximum number of inflorescences per branch (10.33) were found in T_9 treatment followed by T_{10} (9.68) (Fig. 3). Whereas, the minimum number of inflorescences (5.00) was found in treatment T_1 *i.e.,* control. Panchagavya increases crop vigour and growth while simultaneously developing pest and disease resistance (Rakesh *et al.,* 2017). Furthermore, it was asserted that panchagavya spray shows better results as compared to individual nutrients for all crops (Dutta *et al.,* 2016). In the presence of organic manures like FYM and azotobacter, use of bio-fertilizers gives balanced nutrition to the plant. Biofertilizers enhance productivity by dissolving insoluble phosphate, secreting a range of hormones, and biologically fixing nitrogen, in addition to vitamins including thiamine, riboflavin, pyridoxine nicotinic acid and other growth factors required for plant growth (Okan, 1985; Pathak and Ram, 2013). Findings are in accordance with the earlier studies having more blossoms in treated plants of strawberries (Tripathi *et al.,* 2015), banana (Kumar *et al.,* 2025) and apple (Singh *et al.,* 2020).

The maximum length and width of fruits was found in treatment T_9 (11.29 and 6.90 cm). The minimum fruit length and width was found in T_1, i.e., control (8.2 and 4.75 cm) (Table 1), which could be the result of the presence of beneficial microbial population in panchgavya and jivamrit along with availability of macronutrients, micronutrients and growth promoting substances when these are applied on crops as foliar spray and through soil, stimulate plant growth (Binepal *et al.,* 2013; Sivakumar *et al.,* 2001). Furthermore, when combined with biofertilizers, liquid bioenhancers increases the availability of nitrogen and phosphorus, which helps the plant to produce bigger, thinner cells, aids in cell division and elongation and encourages vegetative growth. Eventually this boosts photosynthesis and metabolic activity to increase the plant's biological effectiveness (Tripathi *et al.,* 2017). The present

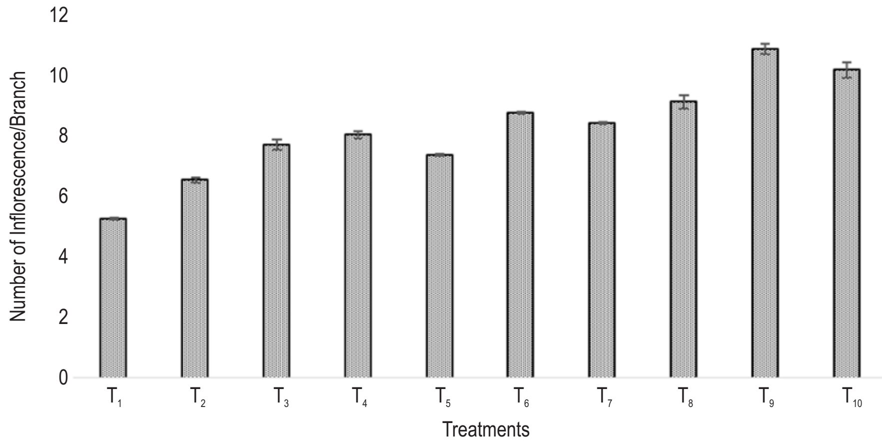

Fig. 3: Effect of bio-enhancers and bio-fertilizers on the number of inflorescences per branch. *Values in the figure are mean ±S.E.

Table 1: Effect of bio-enhancers and bio-fertilizers on physical fruit quality parameters of mango

Treatments	Treatments	Fruit length (cm)	Fruit width (cm)	Average fruit weight (g/fruit)	Fruit volume (g/cc)	Fruit Yield (Kg per tree)	Specific gravity
T_1	T [Control (Water spray)]	8.20	4.75	160.88	178.76	34.10	0.90
T_2	Amrit pani (20 %) + Azotobacter (50 gm / tree)	9.10	4.95	166.88	181.39	41.87	0.92
T_3	Panchagavya (3 %) + Azotobacter (50 gm / tree)	9.95	5.25	180.35	191.86	36.58	0.94
T_4	Jiva amrit (20 %) + Azotobacter (50 gm / tree)	9.65	5.00	172.98	186.00	44.02	0.93
T_5	Amrit pani (20 %) + PSB culture (50 gm / tree)	9.35	5.45	186.25	198.14	50.73	0.94
T_6	Panchagavya (3 %) + PSB culture (50 gm / tree)	10.65	5.95	210.68	219.46	48.66	0.96
T_7	Jiva amrit (20 %) + PSB culture (50 gm / tree)	10.45	5.65	198.65	209.10	51.28	0.95
T_8	Amrit pani (20 %) + PSB culture (50 gm / tree) + Azotobacter (50 gm / tree)	10.20	6.10	225.18	234.56	54.07	0.96
T_9	Panchagavya (3 %) + PSB culture (50 gm / tree) + Azotobacter (50 gm / tree)	11.30	6.90	258.63	263.91	56.69	0.98
T_{10}	Jiva amrit (20 %) + PSB culture (50 gm / tree) + Azotobacter (50 gm / tree)	11.00	6.35	245.23	252.81	33.28	0.97
C.D.	C.D.	0.38	0.28	5.40	10.52	2.39	0.05
SE(m)	SE(m)	0.13	0.09	1.80	3.51	0.79	0.02

findings corroborate with the previous report that Azotobacter and PSB application in strawberries @ 6 kg ha^{-1} resulted in largest fruit size (Mishra *et al.,* 2011). The maximum fruit weight was found in treatment T_9 (258.63g) whereas minimum (160.88g) was recorded in T_{10} (Table 1). Bigger fruit size may be due to efficient photosynthesis and translocation of photosynthates to the developing sinks (fruits) (Tripathi *et al.,* 2016). Use of panchagavya may have reduced floral shed and boosted fruit set through hormonal regulation and/ nutrients availability. The higher biological efficiency of panchgavya treated plants might be due to improved nutrient availability, growth promoting compounds and chlorophyll synthesis (Somasundaram *et al.,* 2007; Tharmaraj *et al.,* 2011).

The maximum fruit volume was recorded from mango plants treated with T_9 (263.907 cc) whereas the minimum (178.757 cc) in T_1 (control) (Table 1). Panchagavya is a viable and sustainable alternative to chemical fertilizers. Its application has been reported to positively influence the fruit yield, quality and vegetative growth in mango (Tripathi *et al.,* 2016). The combined application of biofertilizers, panchagavya and FYM improves fruiting attributes of the mangoes, as trees store more food material and uses it efficiently for fruit development. (Nayyer *et al.,* 2014). Similar increase in fruit volume with panchagavya, FYM and bio-fertilizers have been observed in other crops like aonla and strawberries, likely due to enhanced accumulation and utilization of assimilates during fruit growth (Sreenivasa *et al.,* 2010).

The maximum fruit yield was recorded in T_9 (56.69 kg per tree) whereas minimum (34.10 kg per tree) in T_1, *i.e.,* control (Table 2). Brar *et al.,* (2019) reported an increase in the availability of nutrients, as well as microorganisms, particularly beneficial

Table 2: Effect of bio-enhancers and bio-fertilizers on chemical fruit quality parameters of mango

S. No.	Treatments	TSS (%)	Acidity (%)	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)	Carotenoids (mg $100g^{-1}$)
T_1	Control (Water spray)	17.20	0.50	15.02	7.20	7.82	8.02
T_2	Amrit pani (20 %) + Azotobacter (50 gm / tree)	17.80	0.47	16.00	6.90	9.10	8.22
T_3	Panchagavya (3 %) + Azotobacter (50 gm / tree)	18.40	0.42	16.51	6.34	10.17	8.32
T_4	Jiva amrit (20 %) + Azotobacter (50 gm / tree)	18.20	0.45	16.22	6.68	9.54	8.27
T_5	Amrit pani (20 %) + PSB culture (50 gm / tree)	18.60	0.40	16.87	6.02	10.85	8.36
T_6	Panchagavya (3 %) + PSB culture (50 gm / tree)	19.00	0.33	17.32	5.43	11.89	8.48
T_7	Jiva amrit (20 %) + PSB culture (50 gm / tree)	18.80	0.36	17.06	5.96	11.10	8.41
T_8	Amrit pani (20 %) + PSB culture (50 gm / tree) + Azotobacter (50 gm / tree)	19.20	0.24	18.65	4.89	13.76	8.52
T_9	Panchagavya (3 %) + PSB culture (50 gm / tree) + Azotobacter (50 gm / tree)	20.20	0.12	21.35	4.46	16.89	8.68
T_{10}	Jiva amrit (20 %) + PSB culture (50 gm / tree) + Azotobacter (50 gm / tree)	19.80	0.18	20.80	4.72	16.08	8.59
	C.D.	0.93	0.02	0.90	0.18	0.60	0.37
	SE(m)	0.31	0.01	0.30	0.06	0.20	0.12

bacteria due to application of panchagavya, jivamrit, amritpani and bio-fertilizers. The presence of naturally occurring microorganisms (bacteria, yeast, actinomycetes, and photosynthetic bacteria) improves plant development, metabolic processes, and resistance to pests and diseases (Swaminanthan *et al.,* 2007). Increase in fruit yield may be due to the availability of nutrients, which accelerates dry matter accumulation and also enhance the yield (Gupta *et al.,* 2012; Nayyer *et al.,* 2014; Patel *et al.,* 2018; Bhattacharya *et al.,* 2021).

The maximum specific gravity of the fruit at maturity was noted in T_9 (0.98 g cm^{-3}), however, the minimum was observed in T_1 (0.89 g cm^{-3}) (Table 1). The enhanced organic matter and nutrient availability provided by the treatments may have facilitated the uptake of minerals and nutrients by the plants. Similar findings have been reported in strawberries, where the combined application of organic manures and bio-fertilizers improved plant development (Verma and Rao, 2013; Singh *et al.,* 2015). The present findings are in accordance with the earlier reports of Aal *et al.* (2020) in aonla, Patel *et al.* (2017) in sapota and Nurbhanej *et al.* (2016) in acid lime. The maximum total soluble solids were found in the fruits of T9 (20.2 °Brix) and minimum in the fruits of T_1 (17.2 °Brix) (Table 2).

More TSS content in fruits may be due to enhanced metabolic process by biofertilizer and conversion of starch and pectin into soluble compounds (Gangadhar *et al.,* 2020; Sahana *et al.,* 2020). The minimum titratable acidity at full ripe stage was recorded in the fruits of T_9 (0.12 %). In contrast, the maximum titratable acidity was noted in the fruits of T_1 (0.50%) (Table 2). Decrease in the titratable acidity was noticed in the fruits of bioenhancers and biofertilizers treated plants, which could be due to increase in the conversion of acids to sugars through a reaction involving the reversal of glycolytic pathway and use in the respiration or combination of both (Yadav *et al.,* 2011; Jhade *et al.,* 2020). Early fruit ripening in bioenhancer and biofertilizer treated plants might have caused the breakdown of acid (Yashasvi *et al.,* 2021). The minimum reducing sugars were noted in T_9 (4.46%) and maximum in T_1 (7.20%) (Table 2). The significant increase in the reducing sugars may be due to the application of biofertilizers, which are rich source of available nutrients. These results are in conformity with the findings of Kaul and Bhatanagar (2006) in kinnow and Kashyap *et al.* (2012) in mandrin. Bhatt *et al.* (2012) and Sharma *et al.* (2013) found that biofertilizer application causes efficient conversion of starch and polysaccharides into simple sugar with the advancement of storage. The maximum non reducing sugars were noted in T_9 (16.89%) and minimum (7.82%) in T_1 (Table 2). Fertilizing fruits with the organic fertilizers increases their non-reducing sugar content. Application of biofertilizers enhances fruit quality may be through improved conversion of starch to simple sugars. These findings are in accordance with the reports of Bhatt *et al.* (2012) and Binepal *et al.* (2013) in guava.

The maximum content carotenoids were found in T_9 (8.68 mg $100g^{-1}$) whereas minimum (8.02 mg $100g^{-1}$) in the fruits of T_1 (Table 2). Earlier, Patel *et al.* (2018) also reported similar findings in mango. In organic liquid nutrients more potassium is available (Mahalakshmi and Naveena, 2016). Available potassium increases quality of fruit (Asaduzzaman and Asao, 2018). An adequate nutrients supplementation through application of biofertilizers may regulate different physiological and biochemical processes within plant leading to improved yield and quality of fruits (Patel *et al.,* 2018). Sufficient availability of macro and micronutrients could have boosted the synthesis of pigments.

Pre-flowering and post fruit-set application of biofertilizers and bioenhancers is a sustainable and ecofriendly approach to enhance yield and quality of mango fruits. This leads to reduced application of chemical fertilizers improving soil health. Mango is a perennial fruit crop, hence, improving soil flora and fauna through application of biofertilizers and bioenhancers may help to improve availability of macro-and-micro nutrients indispensable for different plant processes. Application of bioenhancers and biofertilizers is an appropriate strategy to enhance sustainable mango production.

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