Effect of bio-enhancers and bio-fertilizers on growth and quality of Mango cv. Amrapali under sub-tropical plains of Central Uttar Pradesh, India

ABSTRACT

A Field experiment was conducted in the Garden of Department of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) during 2020-2021**.** The experiment was laid out in randomized block design with seven treatments *i.e.,* FYM (25 kg/tree/year) + Organic mulch (Paddy straw) *i.e.,* Control, FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Amritpani (20%) + *Azotobacter* (100g/tree), FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree), FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + *Azotobacter* (100g/tree), FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Amritpani (20%) + PSB culture (100g/tree), FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + PSB culture (100g/tree), FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + PSB culture (100g/tree) which were replicated thrice using one plant as a unit per treatment. The mango cultivar **"**Amrapali**"** was treated with different organic materials like farm yard manure, organic mulch (Paddy straw), *Azotobacter*, PSB culture, Panchagavya (3%), Jivamrit (20%) and Amritpani (20%) respectively and compared with the control.

The experimental results revealed that plants treated with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree) recorded a significantly higher number of leaves per shoot, number of inflorescence per branch, maximum TSS, total sugar content, sugar: acid ratio and is at par with application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + PSB culture (100g/tree) (14.67) and FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + *Azotobacter* (100g/tree). Thus, on the basis of the above observations, this can be suggested that for getting substantially more vegetative growth and quality fruits,

the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree) should be made under the sub-tropical plains of Central Uttar Pradesh, India.

Keywords: Mango, Amrapali, *Azotobacter*, Panchagavya, Growth, Quality.

1. Introduction:

Mango (*Mangifera indica* L.), a member of family Anacardiaceae, is considered the most popular and delicious fruit cultivated mostly in the tropical and sub-tropical parts of the world. Mango is a rich source of β-carotene and vitamin-A, vitamin-B complex, vitamin-C, nutritive minerals, digestible sugars and trace elements. The increased use of inorganic chemicals which is costly for the farmers and also poses harmful effects on the soil and plant health is also an important deliberation for the use of organic nutrients enriched with biological organisms.

The use of bio-enhancers like Panchagavya, Jivamrit which are prepared through the process of fermenting the different cow products over a specific period of time. They enhance the quality of fruits and improve the yield attributes of crops. In fact, bio-enhancers are usually used for all crop activities such as seeds/seedings treatment, which enhances the quick decomposition of biomass, improves the nutritive value of compost, and thereby results in higher soil fertility, crop quality, and crop productivity. They are also used as an effective tool for pest and disease management, act as a potent source of all macro, micronutrients, PGPR activities, immunity enhancers and drought resistance.

Panchagavya, is one of the bio-enhancer which is prepared from five different natural products, that are cow-dung, cow-urine, milk, curd and ghee. These natural products are usually obtained from Desi indigenous cows. Panchagavya have the presence of different important microbes *i.e.*, aerobic heterotrophic bacteria, lactic acid bacteria, yeast, fungi and anaerobic bacteria which will boost the growth and enhance the yield also. Amritpani, it is an

important bio-enhancer, which can easily be prepared by farmers. The available micro-organism in Amritpani are *Actinomycetes*, *Pseudomonas*, Phosphorous solubilising bacteria, *Azotobacter* and *Azospirilum*. Jivamrit, is also prepared the same as Amritpani except the addition of some other ingredients such as jaggery and pulse flour and banyan tree soil. The micro-organism in Jivamrit is also more or less the same as Amritpani. **(Pathak and Ram, 2013).**

Bio-fertilizers are the living or latent cells of different nitrogen-fixing and phosphorus-solubilizing microorganisms which have the capacity of mobilizing the soil nutrients in the soil from unavailable to available form through the different biological processes in the soil. Among the nitrogen-fixing bio-fertilizers, *Azotobacter* have the capacity of fixing about 15–20 kg atmospheric nitrogen per hectare. *Azotobacter* bio-fertilizers is reported to enhance plant growth and ultimately improving the yield. Phosphate Solubilizing Bacteria (PSB) is used as inoculant which simultaneously increases the phosphorus uptake by the plant and thereby results in augmenting the crop yield **(Tripathi *et al.*, 2017).** The P-solubilizers containing bacteria or fungi may convert the insoluble form of phosphate to a soluble form by producing organic acids. The application of phosphate bio-fertilizers also enhances the growth and yield of the crop and enriches soil fertility. Thus, keeping the above fact in view, an experiment was conducted to assess the Influence of bio-enhancers and bio-fertilizers on growth and quality of mango cv. Amrapali in plains of Central Uttar Pradesh.

2. Materials and Method

A Field experiment was conducted in the Garden, Department of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) during 2020-21. The experimental site is located at 25^0 26′ N latitude and 79^0 31 ′E longitude at an elevation of 125.90 meters above mean sea level falling in the alluvial belt of Gangatic plains located in the central part of Uttar Pradesh. The climate of this place is sub-tropical in nature with hot dry summer and cold winters. The soil of the experimental field was sandy loam in texture, and slightly

alkaline in reaction, low in organic carbon, available nitrogen but medium in available phosphorus and potassium with electrical conductivity in the safer range (Table 1).

Table 1. Properties of soil

Soil type	Ph	EC (dS /m)	O.C. (g/kg)	Available N (kg/ ha)	Available P (kg/ ha)	Available K (kg/ ha)
Sandy loam	7.3	0.46	3.9	188.89	21.63	263.13

The experiment was laid out in randomized block design which consisted of seven treatments *i.e.*, T_1: FYM (25 kg/tree/year) + Organic mulch (Paddy straw) *i.e.*, Control, T_2: FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Amritpani (20%) + *Azotobacter* (100g/tree), T_3: FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree), T_4: FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + *Azotobacter* (100g/tree), T_5: FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Amritpani (20%) + PSB culture (100g/tree), T_6: FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + PSB culture (100g/tree), T_7: FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + PSB culture (100g/tree) which were replicated thrice using one plant as a unit per treatment. However, application of bio-enhancers and bio-fertilizers was applied as per the requirement of the treatments (Table 2). The foliar sprays of bio-enhancers and bio-fertilizers were done before and after flowering. For the foliar application of spray on mango plant such as to adequately drench the entire foliage, 10 litres of solution was used for the spraying which is done by using pneumatic foot sprayer fitted with nozzle in the afternoon from 4.00 pm to 6.00 pm. For spraying on top of plant, high legged stool was used to fully ensured that all side of the plant was drenched completely. To avoid the spread of surplus spray under the plants, the polythene sheets were spread on the soil so that spray drops may not reach to the soil.

Table 2: Method of preparation of a solution of nutrients

S. No.	Materials used	Concentrations	Weight of bio-enhancer/bio-fertilizer (per litre of water)
1.	FYM	25 kg/tree/year	-
2.	Organic mulch	Paddy straw	-
3.	Panchagavya	3.0 %	30 ml
4.	Jivamrit	20.0%	200 ml
5.	Amritpani	20.0 %	200 ml
6.	*Azotobacter*	100g/tree	10 g
7.	PSB culture	100g/tree	10 g

Data pertaining to growth attributes were recorded by selecting the five branches which were marked and tagged to record the observation while duration to flowering was recorded by visual observations. However, data related to quality were noted from the harvested fruits. The data were analyzed following the method described by **Gomez and Gomez (1984).** Significant difference of sources of variation was tested at the probability level of 0.05. The standard error of the mean (SEm±) and the CD value were indicated in the tables to compare the difference between the mean values.

3. RESULTS AND DISCUSSION

1. Growth and flowering attributes

The data related to growth and flowering attributes *viz.* duration of flowering, number of leaves per shoot and number of inflorescence per branch have shown significant effect of bio-enhancer and bio-fertilizers in mango plant.

Duration of flowering:

The persual of data related to the duration of flowering presented in Table 3 clearly revealed that, the minimum duration to flowering (15.33 days) was recorded with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree) (15.33 days) which was at

par with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + PSB culture (100g/tree) which took 16.33 days and application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + *Azotobacter* (100g/tree) (17.33 days). However, the maximum duration to flowering was observed with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) *i.e.,* Control (21.33 days). This may be due to the fact that panchagavya, a liquid bio-enhancer that is formed from the combination of different organic products such as cow milk, cow urine, cow dung, cow ghee, cow curd is likely to promote the growth and development of the plant as it is rich in several major mineral nutrients like Nitrogen, Phosphorus, potassium and other micro-nutrients **(Rakesh *et al.,* 2017).** Further, by using bio-fertilizers in greater quantities, soil nutrients and nitrogen fixation is increased (**Binepal *et al.,* 2013**), plant growth stimulants are produced, soil stability is improved, biological control is provided to the mango plant, nutrients are recycled, and mycorrhiza symbiosis is promoted (**Sivakumar, 2001),** all of which contribute to improved plant growth and yield related factors. Additionally, because bio-fertilizers release more nutrients into the soil over time, they can improve soil fertility and productivity per unit area quickly. Due to their involvement in providing macronutrients, important micronutrients, many vitamins, necessary amino acids, growth promoting compounds, and advantageous microbes, **Tripathi *et al.,* (2017), Mishra & Tripathi (2011) and Tripathi *et al.,* (2016)** in strawberry also showed similar outcomes of growth enhancement using different bio-fertilizers.

Number of leaves per shoots:

It is clearly evident from the data given Table-3 that the maximum number of leaves per shoot was recorded with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree) (33.00) which was at par with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + PSB culture (100g/tree) (30.67) and application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit

(20%) + *Azotobacter* (100g/tree) (29.00). However, the minimum number of leaves per shoots was observed with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) *i.e.*, Control (22.33). This may be due to fact that foliar application of Panchagavya applied topically always results in larger leaves and a denser canopy **(Somasundaram *et al*., 2007**; **Tharmaraj *et al*., 2011).** The use of bio-fertilizers significantly enhanced the soil's microbial population, enhancing the soil's ability to support plant growth and productivity. **Nayyer *et al*., (2014) and Tripathi (2017)** in banana recorded more or less similar result are in agreement with the present finding. In addition, panchagavya **(Sreenivasa *et al*., 2010)** contains numerous vitamins, amino acids, and plant growth regulators like auxins and gibberellins. It is also rich in beneficial microorganisms like Pseudomonas, *Azotobacter* and Phosphorous solubilizing bacteria etc. **(Singh *et al*., 2018).** which further promotes the growth of the tree. Thus, biofertilizers and liquid organic product (Panchagavya) have been shown to have a good impact on the vegetative growth of the mango industry. **(Chaudhary, 2010).**

Number of inflorescence per branch:

From the data presented in Table-3, it is reported that the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree) recorded the maximum number of inflorescence per branch (9.33) which was found to be statistically at par with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + PSB culture (100g/tree) (8.67) and application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + *Azotobacter* (100g/tree) which produced 8.33 inflorescence per branch. However, application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) *i.e.,* Control recorded the minimum number of inflorescence per branch (5.33). The integration of panchagavya, bio-fertilizers, and farm yard waste may be responsible for the increase in inflorescences per branch because panchagavya promotes crop growth and vigor while also fostering

resistance to pests and diseases. Additionally, it was claimed that panchagavya spray was more effective on all crops than the recommended nutrients. It increased production and growth. Additionally, the use of bio-fertilizers provides balanced nourishment to the plants when *Azotobacter* and organic manures like FYM are present. By biologically fixing nitrogen, dissolving insoluble phosphate, secreting a variety of hormones, vitamins like thiamine, riboflavin, pyridoxine, and nicotinic acid, among other growth elements necessary for plant growth, they increased productivity, **Okan, (1985), Pathak and Ram, (2013).** These outcomes are consistent with the findings of **Tripathi *et al.*, (2015), Tripathi *et al.*, (2014) and Awasthi *et al.*, (2017)** in strawberry, which have more numbers of flowers/plant.

Table 3: Influence of bio-enhancers and bio-fertilizers on the growth parameters of mango (*Mangifera indica* L.)

S.No.	Treatments	Duration of flowering (days)	Number of leaves/Shoot	Number of inflorescence/ branch
T_1	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) *i.e.* Control	21.33	22.33	5.33
T_2	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Amritpani (20%) + *Azotobacter* (100g/tree)	19.67	25.33	7.33
T_3	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree)	15.33	33.00	9.33
T_4	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + *Azotobacter*(100g/tree)	17.33	29.00	8.33
T_5	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Amritpani (20%) + PSB culture (100g/tree)	20.67	24.67	6.67
T_6	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + PSB culture (100g/tree)	16.33	30.67	8.67
T_7	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + PSB culture (100g/tree)	18.67	27.33	7.67
SEm±		1.298	0.784	0.487
CD at 5%		3.829	2.313	1.439

Quality parameters

Total soluble solids (TSS):

The data related to total soluble solid (Table 4) revealed that the maximum total soluble solid was recorded in mango fruits which were produced from the plants treated with FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree) (19.55 ^{0}Brix) which was statistically at par with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + PSB culture (100g/tree) (19.24 ^{0}Brix) and FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + *Azotobacter* (100g/tree) (18.69^{0}Brix). The minimum total soluble solid was recorded in fruits which were produced from the plants treated with FYM (25 kg/tree/year) + Organic mulch (Paddy straw) *i.e.,* Control (17.17 ^{0}Brix). The outcomes are consistent with those revealed by **Tripathi *et al*., 2014** in strawberry **and Nayyer *et al.* (2014) and Tripathi *et al*., 2017** in banana who noted an increase in these parameters under the organic production system. According to **Rakesh *et al.* (2017),** the application of Panchagavya raised the TSS content of fruits. The application of panchagavya may have enhanced the amount of nitrogen which is available for the formation of secondary metabolites, including phenols, which serve as a natural defensive mechanism for plants. According to the study, using panchagavya improved yield parameters as well as phytochemicals, including carotenoids, phenolic compounds, ascorbic acid, and antioxidant capacity.

Total sugars content (%)

The data related to total sugar content presented in Table-4 revealed that, the maximum total sugar content was recorded in mango fruits which were produced from the plants which were treated with the application of FYM (25 kg/tree/year) + Organic mulching (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree) (17.71%) which was statistically at par with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + PSB culture (100g/tree) (17.41%) and FYM (25 kg/tree/year) + Organic mulch (Paddy straw) +

Jivamrit (20%) + *Azotobacter* (100g/tree) (16.77%). The minimum total sugar content was recorded in fruits which were produced in plants treated with FYM (25 kg/tree/year) + Organic mulch (Paddy straw) *i.e.*, Control (14.71%). This is accordance with the fact that improvement in the chlorophyll and carotenoids content of leaves is obtained by application of Panchagavya may be due to presence of mineral nutrients in it. Similar results were reported by **Sarkar *et al.* (2014) and Rakesh *et al*. (2017)** reported that the total sugar fruit content of fruits increased by application of Panchagavya. These results corroborate the findings of **Mishra *et al*. (2015), Sharma *et al.* (2022) and Awasthi *et al*. (2021) and Tripathi *et al*., 2017** in strawberry.

Titratable acidity content (%):

It was observed from the table-4 that, the minimum titratable acidity content was recorded in fruits which were obtained from mango plants which were treated with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree) (0.30%) which was closely followed with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + PSB culture (100g/tree) (0.34%) and FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + *Azotobacter* (100g/tree) (0.35%). The maximum titratable acidity content was recorded with the application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) *i.e.*, Control (0.48%). This is due to fact that the application of plant bio-enhancers and bio-fertilizers resulted in a decrease in the acidity content of fruits, which may have been caused by an increase in the translocation of carbohydrates and an increase in the metabolic conversion of acids to sugars through a reaction involving the reversal of the glycolytic pathway and used in respiration, or both. **Pathak and Ram (2013)**. Another factor that may have contributed to the reduction in acidity in plants is the use of micronutrients and bio-enhancers in treated fruits. This early ripening of the fruits, which the bio-enhancer caused, may have resulted in the

breakdown of acid. These findings are consistent with **Tripathi *et al*., 2016 and Yashasvi *et al.*, 2021.**

Table 4: Influence of bio-enhancers and bio-fertilizers on the quality parameters of mango (*Mangifera indica* L.)

S.No.	Treatments	Total soluble solids (^{0}Brix)	Total sugar content (%)	Titratable acidity content (%)
T_1	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) *i.e.* Control	17.17	14.71	0.48
T_2	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Amritpani (20%) + *Azotobacter* (100g/tree)	18.09	16.11	0.44
T_3	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree)	19.55	17.71	0.30
T_4	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + *Azotobacter* (100g/tree)	18.69	16.77	0.35
T_5	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Amritpani (20%) + PSB culture (100g/tree)	17.61	15.54	0.45
T_6	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + PSB culture (100g/tree)	19.24	17.41	0.34
T_7	FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Jivamrit (20%) + PSB culture (100g/tree)	18.45	16.45	0.38
SEm±		0.346	0.403	0.015
CD at 5%		1.021	1.189	N.S

4. Conclusion

From the results, it was observed that application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree) recorded a significantly higher number of leaves per shoot, number of inflorescence per branch, maximum TSS, total sugar content, sugar:acid ratio. Thus, it can be concluded that application of FYM (25 kg/tree/year) + Organic mulch (Paddy straw) + Panchagavya (3%) + *Azotobacter* (100g/tree) should be made under the sub-tropical plains of Central Uttar Pradesh, India.

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