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Optimizing fruit yield and quality in mango cv. Langra through integrated nutrient management techniques

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ABSTRACT

The reckless use of chemical fertilizers has led to increase in yield of mango, but at the same time negative effect has been found on soil, water, fruit quality and human health as well. Considering above fact, the experiment was carried out on integrated nutrient management for three consecutive seasons- monsoon (2020), winter (2020) and monsoon (2021) during the year 2020 and 2021. Eight treatments were taken, *i.e.,* T_1- [1000:500:500 g of NPK/tree/year (control / recommended dose fertilizer {RDF})],T_2- [T_1 + Organic mulching 10 cm thick], T_3- [½ RDF + 50 Kg FYM + 250 g *Trichoderma*], T_4-[½ RDF + 50 Kg FYM + 250 g *Azospirillum*], T_5- [½ RDF + 50 kg FYM + 250 g *Azotobacter*], T_6-[½ RDF + 50 Kg FYM + 5 kg Vermicompost], T_7- [½ RDF + 50 Kg FYM + 250 g *Pseudomonas fluorescens*] and T_8-[½ RDF + 50 Kg FYM + 250 g *Trichoderma* + 250 g *Pseudomonas* fluorescens]. T_4 performed better in respect of the maximum number of fruits/ tree (590) and yields (174.91 kg/ tree). The maximum peel (15.18%) and pulp (76.79%) was recorded under T_1, while minimum stone (11.64%) and maximum pulp to stone ratio of 6.62 was observed under T_2. The fruit quality such as maximum TSS of 21.02°Brix, TSS/acid ratio of 87.69, total sugars of 11.82%, total carotenoids of 1.64 mg/100 g, ascorbic acid of 78.45 mg/100 g and minimum acidity of 0.24% was also found in treatment T_4. Therefore, the application of half dose of RDF with 50 Kg FYM and 250 g *Azospirillum* played an indispensable role in increasing the yield and quality of mango cv. Langra.

Key words: Biofertilizer, RDF, vermicompost, yield, organic mulching.

INTRODUCTION

Mango (*Mangifera indica* L.) is the most indispensable fruit crop among all the fruits of India belong to Anacardiaceae family with Indo-Myanmar origin (Darshan *et al*., 4). India is the highest grower of mango in world having share greater than 50% of total production across the world with production of 24.96 million metric tonnes annually covering 2.62 million hectares area (Anon, 1). Being an evergreen fruit crop, it is widely distributed in tropical and subtropical regions. Langra is a crucial mango cultivar of North and Eastern India (Darshan *et al*., 5). It is a mid-season variety with biennial bearing tendency with moderately to good keeping quality. It is more preferred variety due to its high pulp content, firm flesh, lemon yellow colour, thin peel, less fibrous nature *etc*. The average Langra fruit weight varies from 250-350 g/fruit. It covers the more area under cultivation than any other variety of mango grown in Bihar. Apart from being a great source of vitamins, mango has unrivalled nutritional and therapeutic qualities. Ripe mangoes are rich in fats, highly energizing, diuretic, and have laxative properties. The nutritional content of mangoes varies based on their cultivar and level of ripeness. However, they typically have a combination of sugars (16-18% w/v) and acids, as well as significant amounts of antioxidants, including ascorbic acid and polyphenols like carotene (vitamin A) (Hussain *et al*., 6). The stone's interior kernel, which is high in carbohydrate, calcium, and fat, can be used as a food source for some industrial applications. In the last few decades, area and yield under mango cultivation has increased rapidly to meet the growing demands of consumers. Which in return have accelerated the ungoverned use of chemical fertilizers, leading to increasing in yield of mango, but at the same time pessimistic effect has been found on soil, water, fruits quality and our health as well. Since mangoes are primarily eaten fresh, they need to be free of any fertilizer residues. Mango orchard management strategies include nutritional management, pest management, disease management *etc*. out of which nutritional management play key role in yield of fruits. Fertilisers are the most essential inputs, accounting for about 35% of the total cost of cultivation. The indiscriminate application of inorganic chemical fertilisers resulted in massive chemical residues in the field as well as in crop products, posing a variety of environmental and health risks as well as socioeconomic issues (Shukla *et al*., 16). To maintain soil health and achieve high

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yields with improved fruit quality, it is essential to adopt an integrated plant nutrient management (IPNM) approach. This approach optimizes the benefits of all available nutrient sources to sustain the desired level of crop productivity. Chemical fertilisers will be used in concomitance with organic sources such as FYM and vermicompost, as well as bio-fertilizers such as *Azotobacter*, *Azospirillum*, *Trichoderma* and *Pseudomonas fluorescens*, according to IPNM. The goal of this research is to see if organic fertilisers, particularly bio-fertilizers of microbial origin, can be used to augment chemical fertilisers. There has been limited research on the effects of organic, inorganic, and bio-fertilizers on the sustainable production and fruit quality of the Langra mango cultivar. Recommendation for integrated nutrient management system is not yet standardized for the of fruit production in cv. Langra under the climatic conditions of Bihar. With these objectives, an attempt was made to determine the combined effect of organic manures, inorganic manures, and bio-fertilizers on mango fruit yield and quality of mango.

MATERIALS AND METHODS

The present investigation conducted on 35-year-old mango cv. Langra trees to study the effect of integrated plant nutrient management on fruit yield and quality consecutively for three seasons i.e., monsoon (2020), winter (2020) and monsoon (2021) in the department of Horticulture (Fruit and Fruit Technology), BAU, Sabour, Bhagalpur, Bihar during 2020 and 2021. The soil on which the experimental trees were cultivated is alluvial in origin with semi-arid climate and hot summer. Twenty four plants were selected of Langra variety at planted 10 m × 10 m for the experiment. It was laid out on Randomized block Design in three replications with one plant in each replication. All treated plants were treated with the recommended dose of each treatment in the month of August. The experiment has 8 treatments, *i.e.* T_1-[1000:500:500 g of NPK/tree/year (control/RDF)],T_2-[T_1 + Organic mulching 10 cm thick], T_3- [½ RDF + 50 Kg FYM + 250 g *Trichoderma*], T_4-[½ RDF + 50 Kg FYM + 250 g *Azospirillum*], T_5- [½ RDF + 50 Kg FYM + 250 g *Azotobacter*], T_6-[½ RDF + 50 Kg FYM + 5 kg vermicompost], T_7- [½ RDF + 50 Kg FYM + 250 g *Pseudomonas fluorescens*] and T_8-[½ RDF + 50 Kg FYM + 250 g *Trichoderma* + 250 g *Pseudomonas* fluorescens]. Both inorganic and biofertilizer were applied in a ring having depth of 30 cm and 1.5 m distant from main stem in the month of august 2020 and covered properly with soil and biofertilizers were applied after the application of inorganic fertilizers. in the month of august by thoroughly mixing these four inoculums of biofertilizers with 50 kg FYM. The treatment along with mulches were covered with a thickness of 10 cm and kept in the field till attaining the full maturity of fruits in the treatment T_2. The nitrogen was provided in the form of urea, phosphorous in the form Di-ammonium phosphate (DAP) and potassium through murate of potash (MOP). Throughout the study, all the selected young mango plants were managed using consistent cultural practices.

The total number of fruits per tree was determined by manually counting the harvested mangoes once they reached maturity for each replication of every treatment. The yield per mango tree was calculated by multiplying the number of fruits per tree by the average weight of a mango and then dividing by one thousand to express the result in kilograms per tree.

Pulp weight (g) = Total weight of fruit – (Peel weight + stone weight)

Peel weight (g) of fruit is calculated by peeling of the skin of fruits and weighing them individually on electronic weighing balance. Stone weight (g) of mango fruits is calculated by removing stone from mango fruit and washing them properly and then weighing on electronic weighing balance.

The peel, stone and pulp percentage were also calculated as follows:

$$\text{Peel percentage} = \frac{\text{Weight of peel}}{\text{Weight of fruit}} \times 100$$

$$\text{Stone percentage} = \frac{\text{Weight of stone}}{\text{Weight of fruit}} \times 100$$

$$\text{Pulp percentage} = \frac{\text{Weight of pulp}}{\text{Weight of fruit}} \times 100$$

The pulp: stone ratio of mango fruits was calculated by dividing pulp weight to stone weight.

Five mature mango fruits were randomly selected to find out the TSS of fruits. Juice was extracted from the fruit pulp and was measured using digital hand refractometer of range 0-32. Acidity of mango pulp was estimated according to AOAC (2) and the result was expressed in percentage.

$$\text{Acidity (\%)} = \frac{\text{Titre value} \times \text{Normality of NaOH} \times 64 \times \text{volume made up} \times 100}{\text{Aliquot taken} \times \text{weight of sample} \times 1000}$$

Lane and Eynone (9) methods were used to determine total sugars and expressed in per cent.

$$\text{Total sugars (\%)} = \frac{\text{Factor} \times \text{Dilution} \times 100}{\text{Titre value} \times \text{weight of sample}}$$

The TSS-acid ratio was recorded by dividing the TSS of juice with total acidity of pulp then results was expressed in percent. Ascorbic acid in mango pulp was determined and the result was expressed in mg of ascorbic acid per 100 g of fruit juice (AOAC, 2).

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Aliquot taken} \times \text{weight of sample}} \times 100$$

Total carotenoids content of mango was determined by the method of Roy (12).

$$\text{Total carotenoids content}\left(\frac{\text{mg}}{100}\right) = \frac{3.87 \times \text{OD} \times \text{Volumes made up}}{\text{Weight of sample} \times 1000} \times 100$$

The data collected from the field experiment was analyzed using analysis of variance (ANOVA) following the method described by Gomez and Gomez (3) in MS EXCEL. The statistical significance of the experimental results was assessed at a 5% significance level using the "F test." When the F-value was significant, the critical difference (p = 0.05) value was calculated.

RESULTS AND DISCUSSIONS

The data on effect of integrated plant nutrient management on total number of fruits per tree and fruit yield (kg/ tree) is presented in the fig. 1 and fig. 2, respectively. Maximum number of 590.00 fruits and fruit yield (174.91 kg/ tree) was noted under treatment T_4 (½ RDF + 50 kg FYM + 250 g *Azospirillum*) over control. The combined use of organic and inorganic fertilizers synergistically increased the levels of endogenous hormones, such as GA_3 and auxin, in plant cells. This increase may enhance pollen germination and tube elongation, ultimately leading to a higher fruit set and a greater number of fruits per tree (Bhat *et al*., 4). Higher nutrient levels near the plant's root zone promote dry matter synthesis, resulting in more fruits per plant and, consequently, higher fruit yield (kg/plant). These findings align with the results reported by Singh *et al*. (17) and Sau *et al*. (13) in mango.

The perusal of data (Table 1) revealed that the maximum peel percentage (15.18%) was observed in treatment T_1 followed by T_7 and T_6 of 13.46 and 13.04%, respectively. While minimum peel percentage (10.50) in the treatment T_5 (½ RDF+ 50 kg FYM + 250 g *Azotobacter*) was observed. The maximum stone percentage of 16.03 %was observed in treatment T_7 (½ RDF + 50 kg FYM + 250 g *Pseudomonas fluorescens*), while minimum of 11.64 % was noted in treatment T_2 (T_1 + organic mulching 10 cm thick). The maximum pulp percentage (Table 1) are found in treatment T_2 (T_1 + organic mulching 10cm thick) which was of 76.79% showed statistically at par with T_4 of 75.99% and followed by T_5 of 75.93%, while minimum pulp percentage of 70.51% was noted in the treatment T_7. The maximum pulp/ stone ratio (Table 1) of 6.62 was obtained in the treatment T_2 (T_1 + organic mulching 10 cm thick), which remained statistically at par with all the treatments except T_7 while minimum pulp/stone ratio of 4.44 was observed in treatment T_7 (½ RDF + 50 kg FYM

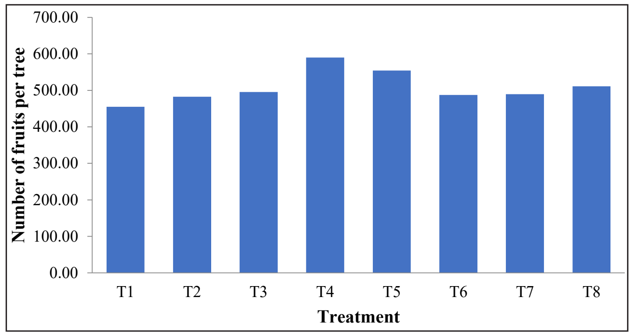

Fig. 1. Effect of Integrated Nutrient Management (INM) strategies on number of fruits per tree in mango cv. Langra.

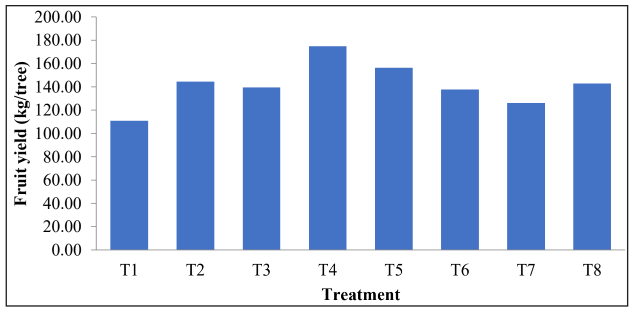

Fig. 2. Effect of Integrated Nutrient Management (INM) strategies on fruit yield (kg/tree) in mango cv. Langra.

+ 250 g *P. fluorescens*). The fruit characters, *viz*., pulp percentage, peel percentage and pulp/stone ratio were improved due to accumulation of more food material. The nutrients application could have resulted in accelerate photosynthesis rate which leads to accumulation of more starch in fruit and ultimately increased fruit weight and size. These findings are in accordance with the findings of Yadav *et al*. (18) and Nehte and Jadhav (10).

Significant variation was reported among different treatments in terms of TSS (Table 2). The maximum TSS (21.02°Brix) was recorded with influence of the treatment T_4 (½ RDF + 50 kg FYM + 250 g *Azospirillum*) followed by 20.10°Brix of TSS with T_5 (½ RDF + 50 kg FYM + 250 g *Azotobacter*), while the minimum of 18.61 with control. Bio-fertiliser helps in fixation and uptake of N_2 that induces the activities of enzymes and TSS content of the juice. These observations are in agreement with the findings of Yadav *et al*. (18) and Sharma *et al*. (13).

The titratable acidity decreased significantly in all the treatments (Table 2). The minimum value of 0.24% was recorded by the application of T_4 (½ RDF + 50 kg FYM + 250 g *Azospirillum*) and it was found statistically at par with T_5 (½ RDF + 50 kg FYM + 250

Table 1. Effect of Integrated Nutrient Management (INM) strategies on peel weight, stone weight, pulp weight and pulp/stone ratio of mango cv. Langra.

Treatment	Peel weight (g)	Peel weight (%)	Stone weight (g)	Stone weight (%)	Pulp weight (g)	Pulp weight (%)	Pulp/ stone ratio
1000:500:500 g NPK/tree (RDF)	36.93	15.18	31.07	12.83	175.67	71.98	5.70
T_1 + Organic mulching 10 cm thick	34.83	11.58	34.83	11.64	231.00	76.79	6.62
½ RDF + 50 Kg FYM + 250 g *Trichoderma*	36.50	13.03	33.90	12.09	210.93	74.87	6.24
½ RDF + 50 Kg FYM + 250 g *Azospirillum*	34.17	11.60	36.37	12.41	226.13	75.99	6.25
½ RDF + 50 Kg FYM + 250 g *Azotobacter*	29.48	10.50	38.07	13.57	214.45	75.93	5.64
½ RDF + 50 Kg FYM + 5 kg Vermicompost	35.37	13.04	40.20	14.72	205.10	72.25	5.10
½ RDF + 50 Kg FYM + 250 g *Pseudomonas fluorescens*	34.67	13.46	41.23	16.03	182.10	70.51	4.44
½ RDF + 50 Kg FYM + 250 g *Trichoderma* + 250 g *pseudomonas fluorescens*	30.43	10.92	40.17	14.43	208.40	74.64	5.20
SEm ±	1.44	0.88	1.17	1.03	18.06	1.78	0.54
CD (5%)	4.35	2.68	3.56	3.13	54.79	5.41	1.65

RDF: Recommended dose of fertilizer.

Table 2. Effect of Integrated Nutrient Management (INM) strategies on total soluble solids (TSS), titratable acidity, TSS/ acid, total sugars, ascorbic acid and total carotenoids of mango cv. Langra.

S. No.	Treatment	TSS (°Brix)	Titratable acidity (%)	TSS/acid ratio	Total sugar (%)	Ascorbic acid (mg/100 g)	Total carotenoids (mg/100 g)
T_1	1000:500:500 g NPK/tree (RDF)	18.61	0.38	48.74	7.97	61.92	1.43
T_2	T_1 + Organic mulching 10 cm thick	19.92	0.37	54.38	8.08	63.32	1.52
T_3	½ RDF + 50 Kg FYM + 250 g *Trichoderma*	19.75	0.28	69.73	9.82	66.98	1.54
T_4	½ RDF + 50 Kg FYM + 250 g *Azospirillum*	21.02	0.24	87.69	11.82	78.45	1.64
T_5	½ RDF + 50 Kg FYM + 250 g *Azotobacter*	20.10	0.25	81.88	11.58	71.22	1.63
T_6	½ RDF + 50 Kg FYM + 5 kg Vermicompost	19.91	0.30	65.68	9.55	65.19	1.53
T_7	½ RDF + 50 Kg FYM + 250 g *Pseudomonas fluorescens*	19.95	0.27	75.22	10.45	69.02	1.58
T_8	½ RDF + 50 Kg FYM + 250 g *Trichoderma* + 250 g *pseudomonas fluorescens*	20.04	0.26	77.57	10.98	70.05	1.59
	SEm ±	0.26	0.01	2.17	0.23	1.72	0.04
	CD (5%)	0.80	0.02	6.58	0.69	5.22	0.12

RDF: Recommended dose of fertilizers.

g *Azotobacter*). However, maximum titratable acidity of 0.38% was observed under treatment T_1 (control). The increase in physiochemical parameters in fruits is due to bio-fertilizer, which plays key role in fixation of N_2, production of substances which enhanced uptake of nitrogen (Nehte and Jadhav, 10).

The total sugar percentage increased significantly in all the treatments (Table 2). Total sugar percentage was recorded maximum (11.82%) in T_4 (½ RDF+ 50 kg FYM + 250 g *Azospirillum*) remained statistically at par with treatment T_5 (½ RDF + 50 kg FYM + 250 g *Azotobacter*) with value of 11.58%. over the control while minimum total sugar (7.97%) present was in T_1. Combined application of chemical and biofertilizers helps in better translocation and absorption of growth promoting substances in which carbohydrate role is of utmost importance and conversion of it into simple sugars resulted in superior fruit qualities. These above results are in conformity with findings of Yadav *et al*. (18). The mechanism of improved quality of fruits was observed by Kaur and Kaur (7).

The maximum TSS/acid (Table 2) was found in the treatment T_4 (½ RDF + 50 kg FYM + 250 g *Azospirillum*) with ratio of 87.69 and remained statistically at par with T_5 (81.88), whereas minimum ratio of 48.74 was recorded in control. TSS/acid ratio was increased due to more accumulation of TSS and reduction in acidity of fruits with the use of biofertilizer. These results are in accordance with findings of Yadav *et al*. (17).

Significant variation was noticed among various treatments with respect to ascorbic acids (Table 2). Maximum ascorbic acids content of 78.45 mg/100 g of pulp was recorded by the effect of treatment T_4 (½ RDF + 50 kg FYM + 250 g *Azospirillum*) while minimum ascorbic are found in T_1 with value of (61.92 mg/100 g of pulp). Higher level of ascorbic acid was obtained due to the use of *Azospirillum* as it helped in formation of higher content of ascorbic acid from sugars. This is mainly due to uninterrupted transfer of nutrients and growth promoter substances. The other researchers had observed the similar findings Sharma *et al*. (15), Kundu and Mishra (8) and Nehte and Jadhav (10).

The present investigation revealed that the carotenoid content increased with the effect of inorganic fertilizers, FYM and bio-fertilizer (Table 2). The maximum total carotenoids content of 1.64 mg/100 g of pulp was obtained by the effect of the treatment T_4 (½ RDF + 50 kg FYM + 250 g *Azospirillum*). The higher total carotenoids content could be described by the fact that these microbial fertilisers help in increasing nutrient availability in the rhizosphere of plants and boosted ability of plants to better absorb more solutes from the vicinity of roots as well as in reducing plant stress (Patil *et al*., 11).

Based on the current research findings, it can be concluded that the treatment T_4, which comprises half the recommended dose of chemical fertilizers (RDF) combined with 50 kg of farmyard manure (FYM) and 250 g of *Azospirillum*, has proven to be the most effective in enhancing several key aspects of mango cultivation. This treatment not only significantly increases the number of fruits per tree but also boosts the overall fruit yield. Additionally, it has a positive impact on various quality parameters of the mango fruits, including increasing the TSS, reducing acidity, elevating total sugars content, improving the TSS/acid ratio, and enhancing the levels of ascorbic acid and carotenoids. These improvements suggest that T_4 treatment offers a comprehensive approach to optimizing both the quantity and quality of mango production.

AUTHORS' DECLARATION

Conceptualisation of research (RK, RK, SK); Designing of the experiment (RK, RK, SK); Execution of field/lab experiment and data collection (RK, SK); Analysis of data and interpretation (RK, SK); Preparation of manuscript (S, AC).

DECLARATION

The authors declares that they have no conflict of interest.

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