Examining the impact of Integrated Fertility Management in Fruit Crops: A Literature Review

Abstract

Efficient nutrient management is crucial for maximizing fruit production, improving quality and ensuring long-term sustainability in agricultural systems. This study examines the contributions of macronutrients, micronutrients and organic fertilizer to improving soil fertility and promoting the establishment of high-quality fruit crops. In addition, the study the influence of chemical fertilizers and plant growth regulators on the physiological processes that are crucial for optimizing fruit yield. The study highlights the importance of integrated nutrient management strategies, that include combining of organic and inorganic input, to achieve a harmonious balance between maximizing fruit harvest and ensuring long-term soil health. The results suggest that this strategy improves the quantity and quality of fruits produced and promotes sustainable agriculture by reducing its impact on the environment. These results provide important information for fruit growers and agronomists who want to maximize fruit yield by implementing balanced and sustainable nutrient management strategies. This approach ensures both immediate agricultural success and long-term conservation of soil and environmental resources for future generations.

Keywords: *Integrated nutrient management, soil fertility, improvement of fruit quality, sustainability in horticulture*

Introduction

Efficient nutrient management is crucial for maximizing fruit production, improving quality and ensuring sustainability in agriculture. The use of chemical fertilizers is widespread to meet the nutrient requirements of crops. However, their excessive use has led to soil degradation, environmental pollution and potential impairment of fruit quality. Given challenges, there is an increasing focus on introducing Integrated Nutrient Management (INM) strategies.

The aim of the INM is to optimize soil conditions, including physical, chemical, biological and hydrological properties, by combining organic and inorganic nutrient sources. This approach balances the use of artificial fertilizers, organic fertilizers, crop residues and biofertilizers, ensuring increased crop productivity while maintaining long-term soil health. According to Mahajan *et al.* (2009), INM promotes a synergistic effect between different nutrient sources, improving soil fertility and reducing dependence on chemical inputs.

Nutrient status of Indian soils

- Indian soils have been found to have low levels of nitrogen (N) and phosphorus (P), with 89 and 80 per cent of soil samples falling into the low to medium category. However, the situation is relatively better regarding potassium (K), with only 50 per cent of samples falling into the low to medium range.
- The elements S, Zn, B, Mo, Fe, Mn and Cu are deficient by 41%, 49%, 33%, 22%, 12%, 5% and 3%, respectively.

Table 1. Nutrient deficiencies status in different states of the Indian Subcontinent (ppm)

States	N	P	K	S	Zn	Fe	Cu	Mn	B
Andhra Pradesh	100	100	58.00	28.90	22.30	16.80	1.00	1.70	2.80
Assam	100	100	82.00	16.70	25.60	00.00	3.80	00	11.90
Bihar	94.00	97.00	96.00	42.80	37.90	9.90	1.90	7.40	36.30
Chhattisgarh	100	100	59.00	-	20.10	6.80	3.20	14.10	-
Gujarat	89.00	100	37.00	42.00	23.10	23.90	0.40	6.30	17.90
Haryana	100	100	39.00	35.80	15.30	21.60	5.20	6.10	3.30
Himachal Pradesh	24.00	88.00	100.0	00.00	11.10	0.80	2.10	3.50	32.00
Jharkhand	100	98.00	79.00	-	20.30	0.00	0.50	0.0	56.00
Karnataka	81.00	96.00	22.00	-	13.50	3.50	2.70	-	-
Kerala	94.00	76.00	82.00	-	1.20	1.30	11.40	-	24.70
Madhya Pradesh	90.00	87.00	46.00	27.70	66.90	10.20	0.60	1.80	1.70
Maharashtra	100	100	21.00	26.50	54.00	21.50	0.20	3.80	54.70
Orissa	100	100	69.00	31.10	22.70	1.80	0.30	1.10	52.50
Punjab	100	47.00	11.00	53.30	16.60	6.20	3.60	15.2	17.50
Rajasthan	100	100.00	24.00	-	85.50	35.50	63.70	-	-
Tamil Nadu	98.00	62.00	32.00	14.30	65.50	10.60	13.00	7.9	19.90
Telangana	-	-	-	31.80	26.90	17.00	1.40	3.80	16.10
Uttar Pradesh	100	100	61.00	32.50	33.10	7.60	6.30	6.50	16.20
Uttarakhand	80.00	100	67.00	11.20	9.90	1.40	1.40	4.70	7.00
West Bengal	100	90.00	19.00	37.40	11.90	0.00	1.20	0.90	46.90
All India	95.00	95.00	48.00	24.70	43.30	14.40	6.10	7.90	20.60

Source: Katyal *et al.* (2016)

Integrated nutrient management began in the late 1980s and it is important to solve the problems related to micronutrient deficiencies and soil health deterioration (Baskar *et al.*, 2022). INM has acquired significant importance in fruit cultivation. These benefits include maintaining health, reducing reliance on chemical fertilizers and minimizing soil pollution. In addition, it provides plants with the necessary nutrients at an affordable price. According to Gaur (2001), this approach effectively prevents nutrient losses and controls the spread of insect pests and diseases.

The INM method is an excellent solution for farmers looking for an alternative to expensive chemical fertilization to feed their crops. In addition, the aim is to improve the condition of the soil by improving its biological, mechanical, hydrological and physical properties. According to Saikia *et al.* (2015), this practice aims to improve agricultural productivity and reduce soil depletion. There is increasing recognition that implementing integrated nutrient management practices can improve crop yields while maintaining soil health. The study discusses various activities to improve soil quality and water management. These activities include the use of various different methods and materials, including FYM, agricultural waste, composts, green manures, fertilizers, intercropping, cover crops, tillage and drainage systems (Wu and Ma, 2015). This approach utilizes state-of-the-art methods, including precise fertilizer placement and application of urea coatings. These methods are carefully designed to improve plant uptake and reduce nutrient losses. (Saikia *et al.*, 2015). These activities allow producers to prioritise sustainable planning and carefully consider environmental impacts rather than just focusing on returns. If you want to achieve integrated nutrient management, you can use different approaches. This includes the incorporation of organic fertilizers such as FYM, vermicompost, organic-fertilizers and inorganic fertilizers.

Farmyard manure (FYM) is a valuable source of nutrients. It contains essential micronutrients and is rich in organic matter. Rai (2014) highlights the numerous benefits of manure for soil. It can increase organic matter content, improve soil structure and drainage in clay soil and increase the water-holding capacity. In addition, manure has numerous benefits for soil health and fertility. It is a valuable source of nutrients that is released slowly over time, and contributes to plant nutrition. In addition, it plays a crucial role in preventing erosion caused by water or wind. Manure also promotes the growth of earthworms and other beneficial microorganisms in the soil, contributing to its overall health.

Vermicompost is a crucial part of integrated nutrient management, showcasing remarkable levels of organic carbon. Critical to maintaining soil fertility, this product provides a full range of essential nutrients in the right proportions, making it a premium option for plants nutrition. This product significantly improves soil fertility and quality by improving its chemical, biological and physical properties (Turyasingura *et al.*, 2023). This product also promotes the development of beneficial substances and microorganisms while preventing the growth of harmful microbes. This has numerous benefits for soil health. The application of vermicompost has significantly increased crop yield, improved nutrient status and improved nutrient absorption. Several studies have demonstrated the positive effects of vermicompost on a number of fruit crops. Singh *et al.* (2008) and Chaurasia *et al.* (2022) found positive effects on strawberry crops, while Acevedo and Pire (2004) observed similar results in papaya crops. Athani and Hulamani (2000) reported positive results in banana cultivation, while Athani *et al.* (2005) found that vermicompost benefits the guava crop. Mahmoud and Gad (2020) also observed positive effects on bean plants and Mahmud *et al.* (2019) reported similar results in pineapple crops.

Bio-fertilizers are essential for integrated nutrient management as they consist of living organisms that improve the supply of primary nutrients to the main crop. These organisms can be applied to seeds, plants, or soil, providing valuable increase in agricultural productivity (Kumar *et al.,* 2018). This type of fertilizer is differ from chemical or organic fertilizers in that it does not directly provide nutrients to plants. Instead, it promotes the growth of certain fungi and bacteria. It is a relatively simple and expensive installation option. Bio-fertilizer has had positive effects on various aspects of plant growth and development. Studies have shown that it can result in higher growth rates, larger trunk girth and improved yield development by 10-40% (Stewart and Roberts, 2012).

Additionally, bio-fertilizers have been found to enhance fruit quality, increase fruit weight and improve the fruit's Total Soluble Solids (TSS) content. Furthermore, it has the added benefit of reducing acidity compared to chemical fertilizers (Alam and Seth., 2014). Hazarika, mango (Poonia *et al.,* 2018) and many more scientists, horticulturists and other pomologists.

Component of INM

The INM system includes a range of organic fertilizers, including FYM, compost, green manure, vermicompost, bio-fertilizers and crop residues. In addition, it requires choosing the right crop varieties, implementing effective cultural management practices and making the most of soil and water resources to achieve successful and suitable crop production.

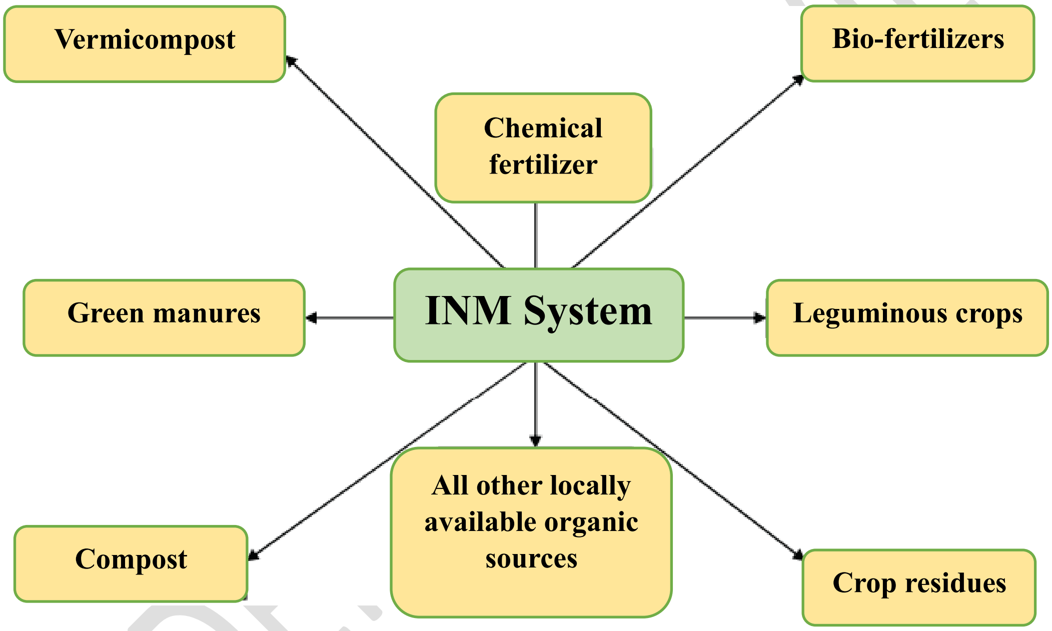

Fig:1. The INM system's component

Therefore, the INM system can potentially enhance crop productivity and improve soil conditions through synergistic effects. The critical components of the INM system include:

1. Including soil fertility and maintaining crops like legumes and green manures can be valuable to your gardening practices.
2. Recycling the crop residues can be a beneficial practice.
3. They are utilising a variety of organic manures such as vermicompost, FYM, biogas, compost, poultry manure, Phosphate-compost, slurry and press mud cakes.
4. Efficient genotypes.
5. Using fertilizer nutrients is carefully balanced to meet the crop's specific needs and maximise yields.
6. The use of biological substances has been explored in a study by Jat *et al.* (2015).

7. The impact of INM on fruit crop yield, growth and quality.

Aonla(*Emblica officinalis*)

Tripathi *et al.*(2015a) experimented on ten-year-old plants of aonlacvNA-7 and found the yielded result with the highest values recorded fruit set at 40.56% (T_9), fruit retention at 34.64% (T_9), fruit drop at 65.35% (T_9), fruit length at 3.70 cm (T_9), fruit width at 4.60 cm (T_9), fruit weight at 50.32 g (T_9) and fruit volume at 42.89 cc (T_9). For chemical traits, seed weight was 2.38 g (T1), total soluble solids (TSS) were 11.40 °Brix (T_5), total sugar content was 6.86% (T_5), ascorbic acid was 542.22 mg (T_5), titratable acidity was 2.37% (T_4). TSS to acid ratio was 4.85 (T_5) under the northern plains of India.

Tripathi *et al.* (2015b) study mimic that a combination of 75% NPK, 4 kg Vermicompost, 100.00g *Azotobacter* and 100.00 g PSB significantly improved fruit set, retention and yield. The treatment also enhanced fruit quality, achieving the highest values for total sugars, ascorbic acid and TSS: acid ratio while decreasing titratable acidity. This suggests that an integrated nutrient management strategy optimizes aonla crops in northern India.

Kumar *et al.* (2023), the researchers explored the impact of integrated nutrient management on the growth, yield and quality of Aonla (cv. NA-7) to assess the effects of this management approach on the plant's overall performance. Significant improvements in various aspects of fruit production. These improvements included increased fruit set, retention, yield and quality attributes such as size, weight and TSS. The treatment yielded the highest ascorbic acid content of 559.27 mg/100.00g pulp and the highest TSS: acid ratio of 9.28. Additionally, it had the lowest titratable acidity of 1.39 %. Based on the research, adopting this integrated nutrient management approach can significantly enhance the yield and quality of Aonla fruit in the Northern plains of the Indian subcontinent.

Ber (*Ziziphus mauritiana*)

In a study, Katiyar *et al.* (2012) investigated the impact of integrated nutrient management on regenerated Ber trees' growth, flowering, fruiting, yield and quality. The 35-year-old trees underwent pruning in 2009 and were subjected to six different NPK treatments, with all treatments supplemented with 50 kg of FYM. The results showed that T5 stimulated plant growth, while T4 improved flowering, fruit formation and fruit quality, resulting in the highest yield of 30.08 kg per tree.

Banana (*Musa* spp.)

Shukla *et al.* (2022) conducted an experiment to evaluate the effect of Integrated Nutrient Management (INM) using a combination of organic and inorganic nutrients and bio-fertilizers on tissue-cultured banana cv's growth, yield and quality. Grand Naine. The results revealed that the application of T7 (75% RDF of P + 100% RDF of NK + 25% FYM + 25% vermicompost + 50g *Azospirillum* + 50g PSB) significantly improved yield parameters, including maximum bunch weight (19.99 kg), number of hands per bunch (11.71), number of fingers per hand (19.29), total fingers per bunch (223.44), finger weight (139.12 g), fruit yield plant^{-1} (31.10 kg), fruit yield (95.79 t/ha), finger length (21.67 cm) and finger girth (17.79 cm).

Shukla *et al.* (2022) experimented to see the integrated approach on the growth of ratooned banana and was revealed that T7 (75% RDF of P + 100% RDF of NK + 25% FYM + 25% vermicompost + 50g *Azospirillum* + 50g PSB) resulted in the maximum plant height (60.25 cm at 60 days to 221.22 cm at 240 days), pseudo stem girth (23.74 cm at 60 days to 67.40 cm at 240 days), number of leaves (9.38 at 60 days to 26.97 at 240 days) and suckers (8.37 at shooting stage). It also recorded the highest leaf area (10.43 m^2), inflorescence length (122.23 cm) and the shortest duration for flowering (282.81 days) and fruit harvest (85.83 days).

Tripathi *et al.* (2017) demonstrated the importance of biofertilizers and evaluated the effects of bio-fertilizers on tissue-cultured banana cv. Grand Naine. The combination of *Azotobacter*, *Azospirillum*, PSB and *Trichoderma harzianum* (50 g each per plant) yielded the most favourable results regarding plant growth and fruit quality. Plants showed the most significant pseudo stem height (146.16 cm), girth (65.33 cm), total leaves (34.33), functional leaves at inflorescence (17.33) and inflorescence length (112.83 cm). Additionally, they achieved the highest bunch weight (22.25 kg), number of fingers per hand and per bunch (16.66 and 143.00) and number of hands per bunch (8.33). Enhanced fruit quality, with the highest finger weight (135.83 g), length (19.16 cm), diameter (15.33 cm), TSS (19.00° Brix), total sugars (18.68%), pulp content (80.86%) and favourable pulp-to-peel ratio (4.22), with minimised peel content (19.14%) and acidity (0.47%).

In a study conducted by Patil and Shinde (2013), it was procured that the application of T3, which included 50% RDF, farmyard manure, PSB, *Azotobacter* and VAM, resulted in the highest leaf number (32.30), maximum leaf area (17.93 m^2), girth (81.34 cm) and height (190.84 cm) in banana cv. Ardhapuri. In addition, the factors contributing to yield, such as yield (85.80 t/ha) and bunch weight (19.31 kg), were higher in T_3. Based on the findings, it was observed that using a combination of RDF 50%, Farmyard manure, PSB 50 g, *Azotobacter* 50 g and 250g VAM per plant positively impacted the yield and growth of banana.

The findings of Tripathi (2020) from the study on the ratoon banana crop indicate that the treatment involving 100% RDF of NPK, along with 50g of *Azospirillum*, 50g of PSB and 50g of *Trichoderma harzianum* per plant, resulted in the tallest plants (145.45 cm) with the largest circumference of pseudo stem (64.00 cm). These plants also had the highest number of leaves (30.60) per plant, longest inflorescence (105.80 cm), most significant number of fingers per hand (17.66) and per bunch (140.00), most extended finger length (19.33 cm), heaviest finger weight (138.00 g), widest finger diameter (15.10 cm), highest levels of total soluble solids (17.98 ° Brix) and total sugars (17.20%) and the highest pulp content (80.36%) and pulp-to-peel ratio (4.58). Additionally, this treatment required the shortest duration (232.33 days) from planting to flowering or the emergence of the bunch and resulted in the lowest levels of titratable acidity (0.42%) and peel content (17.36%). My suggestion isto become the most economical and eco-friendly for the livelihood farmers of the North Plains of the Indian subcontinent.

Kuttimani *et al.* (2013) charted that the application of RDF 100% + Wellgro soil 40% resulted in higher corm diameter (79.17 and 79.17 cm), root numbers (242.57 and 233.00) and corm volumes (4.10 and 4.73 lit $plant^{-1}$). There has been a significant rise in RDF by 100% when using either 40% Wellgro soil or 10 kg FYM $plant^{-1}$ over the course of both experimental years. This increase has been observed in various growth parameters, including the leaf area index, crop growth, net assimilation rate, relative rate of growth and absolute rate of growth, as well as in physiological parameters such as nitrate reductase activity, soluble protein and total chlorophyll content. Therefore, integrated nutrient management approaches are the most suitable option for maximizing banana growth and physiological parameters.

A study conducted by Bhalerao *et al.* (2009) discerned that the treatment consisting of a 100% recommended dose of fertilizer (RDF) along with 10 kg of farmyard manure (FYM), 25 g of phosphate solubilising bacteria (PSB) and 25 g of *Azospirillum*had a positive impact on the yield of banana. This treatment showed similar results to the treatment that combined 50% of the NPK nutrients from inorganic and bio-fertilizers with 50% from organic sources such as green manure and FYM. In addition, it has been noted that relying solely on organic manure is insufficient for achieving maximum production compared to integrated nutrient management.

Nayyer *et al.* (2014) found that Banana cv. Grand Naine plants treated with RDF 100% + *Azospirillum* 50 g + *T.harzianum* 50g + 50 g PSB /plant exhibited higher pseudo girth (67.98cm), stem height (150.27 cm), inflorescence length (118.50 cm) and leaf numbers (34.66). These plants also showed early flowering (253.33 days) and a shorter time from flowering to bunch harvesting (110.00 days) than other treatments. Similar treatment also resulted in significant improvements in the following parameters: finger numbers per hand (19.33), finger numbers per bunch (160.00), bunch weight (24.50 kg), finger weight (140.00 g), diameter (15.20 cm), length (20.33 cm), pulp percentage (82.17%), total sugars (18.66%), TSS (19.26 °B) and pulp to peel ratio (4.60). Additionally, the treatment led to a decrease in titratable acidity to a minimum of 0.40 %.

Mango (*Mangifera indica*)

In their study conducted at the Khagrachari site, Zonayet *et al.* (2020) found that the T_4 treatment (150% of T_2) resulted in the highest mango yield of 22.30 kg/plant. At the Bandarban site, the T_3 treatment produced the highest mango yield of 48.25 kg per plant, 125% higher than the T_2 treatment. At the Rangamati site, the T_4 treatment produced the highest mango yield of 23.10 kg per plant, which is 150% of the T_2 treatment.

Vala *et al.* (2020) provided a thorough analysis of the findings. Based on my analysis of the data from the past four years, treatment T_7 showed impressive results. It had the highest plant height of 5.33 m, maximum plant spread (E-W) of 4.34 m, plant spread (N-S) of 3.97 m, fruit circumference of 9.53 cm, fruit length of 8.76 cm, fruit weight of 185.50 g, fruit yield of 18.40 kg/plant and 3271 kg/ha, total sugar content of 14.78 % and TSS of 26.81 %. The treatment that combined 50% nitrogen from RDF and 50% nitrogen from Castor Cake per kilogram per year demonstrated superior results compared to other treatments.

Nehete and Jadav (2019) found impressive results regarding the Mango cv. Amrapali. The application of (T_{13}) N 70% + P_2O_5 85% + PSB + *Azotobacter* led to the highest TSS (21.43 %), Total sugar (18.82 %), maximum Ascorbic acid (42.76 mg) and Reducing sugars (8.80 %) compared to the other treatments. It was observed that the highest yield of 54.00 kg/tree was achieved with the application of N 85% + P_2O_5 85% + PSB + *Azotobacter* (T_{10}).

This treatment showed a close relationship with the combination of 85% N + 100% P2O5 + PSB + *Azotobacter* (T_8) and 70% N + 85% P2O5 + PSB + *Azotobacter* (T_{13}).

In a study conducted by Gautam *et al.* (2012) found that the treatment T8, which included N 500g + P 250g + K 250g /tree + vermicompost 10 kg + 50 kg FYM, had a positive impact on various yield contributing parameters. This treatment increased the number of fruits/panicles, fruit yield, fruit width, length, weight, pulp weight and vegetative growth parameters such as maximum canopy or plant spreading (E-W) and (N-S) and plant height. These findings suggest that the T8 treatment is superior to other therapies in enhancing the overall performance of cv. Sunderja.

Yadav *et al.* (2011) opined some interesting findings about the physical parameters of cv. Amrapali. The highest fruit width was measured at 6.62 and 6.48 cm, while the fruit length was 9.88 and 10.08 cm. The weight of the fruit was found to be 151.25 and 153.00 g, with the stone weight being 26.45 and 26.62 g. The pulp weight was recorded as 97.06 and 97.08 g. The maximum TSS was also measured at 23.72 and 23.91°Brix and the pulp: stone ratio was 3.693 and 3.694. The study also observed the number of flowers (1710.67 and 1756.00), sex ratio (0.690 and 0.691), number of fruits per tree (163.33 and 184.67), fruit set (194.67 and 201.33) and fruit yield (25.00 and 26.72 q/ha). The treatment of T8, which consisted of RDF of NPK + PSB + *Azotobacter* + vermicompost + paclobutrazol+ Fe + Zn, showed the closest results to the desired parameters. T12, which included RDF of NPK + PSB + *Azotobacter* + BD compost + paclobutrazol + Fe + Zn, also showed promising results over the two experimental years.

Singh *et al.* (2015) found that the T_6 treatment, which included 500g N, 250g P and 250g K per tree per year, along with 250 g *Azospirillium* and 50kg FYM, resulted in the highest tree height (108.00 cm), fruit weight (263.10 g), plant spread in the N-S (105 cm) and E-W (123cm) direction, tree volume (85.95 m^3), total number of fruits (234.12) and yield per tree (58.56 kg) compared to the other treatments.

Hasan *et al.* (2013) systemised that applying vermicompost with a specific combination of nutrients significantly improved various aspects of Mango Fruit cv. Himsagar. The fruit length increased to 9.53 cm, weight to 273.20 g and TSS reached 21.57 °Brix. Additionally, the pulp weight increased to 180.20; total sugar content increased to 11.32%; ascorbic acid content reached 25.68 mg per 100.00g and pulp content increased to 65.96%. Furthermore, this treatment had the lowest acid content compared to other treatments.

Talang *et al.* (2017) study revealed that specific treatments significantly impacted the growth and yield of mango fruit cv. Himsagar. The T6 treatment, which included half NPK/tree, 50 kg FYM, *Azospirillium* and potassium mobiliser, resulted in an enormous stem girth, tallest plant height and widest tree spread. The T_8 treatment, which included half NPK/tree, 50 kg FYM, vermicompost and potassium mobiliser, produced the highest fruit number, yield, weight and total sugars.

A study by Sharma *et al.* (2016) demonstrated that applying a specific combination of nutrients and organic materials to Mango Fruit cv. Amrapali plants can have a positive impact. The application included 520g of nitrogen, 160g of phosphorus and 450g of potassium per plant, along with 25 kg of vermicompost, 2.5 kg of oil cake and various beneficial microorganisms such as PSB, VAM, *Azotobacter* and TV (100g each). The recorded measurements for the crown height, length, width (east-west and north-south), shoot length, number of panicles and length of panicle were all higher than those of the control and other treatments.

Peach (*Prunus persica*)

Solanki *et al.* (2020) noted that the Peach cv. July Elberta showed a significantly higher yield (20.16 kg per tree) and fruit set (87.70%) when treated with RDF 75% + 15 kg vermicompost/tree. This suggests that applying this specific combination of fertilizers can significantly enhance the productivity of Peach trees. The study revealed some impressive findings, such as the cumulative breadth of fruit measuring 61.89 mm, the highest length of fruit at 64.06 mm, total sugar content of 7.51%, a TSS (Total Soluble Solids) measurement of 13.33 ºB and a weight of 129.51 g under the application of RDF 75% + 15 kg vermicompost per tree.

Apricot (*Prunus armeniaca*)

Kumara *et al.* (2024) study on mature "New Castle" apricot trees in Solan, Himachal Pradesh, observed a combination of 50% Nitrogen, *Azotobacter*, Phosphate Solubilizing Bacteria and Vermicompost showed superior performance. This treatment increased trunk girth, leaf chlorophyll content, leaf area, fruit set and yield. It also showed the highest elevated nutrient levels, with T_2 yielding the largest economic returns. The study highlights the benefits of combining organic manures and bio-fertilizers with chemical fertilizers for improved productivity and soil health.

Pomegranate (*Punica granatum*)

Gajbhiye *et al.* (2020) confirmed that the treatment T_7 (INM: Compost + Solubilisers + RDF + Umber (*Ficus racemosa*) Rhizosphere hybridised soil) resulted in the highest fruit set (84.39%), number of flowers (204.75), fruit weight (244.82 g) and yield (41.21 kg/tree) for pomegranate. The treatment T_6 (INM: compost + solubilisers + RDF + Antibiotics) also showed positive results with values such as number of flowers (189.50), maximum fruit set (82.08%), yield (37.53 kg tree^{-1}) and maximum weight (240.49 g) compared to other treatments. On the other hand, the control treatment T_1 had the lowest number of flowers (61.25), minimum fruit set (68.15%), weight (188.38 g) and yield (9.08 kg tree-^{1}).

Papaya (*Carica papaya*)

Singh and Tripathi (2020) recorded various traits which was positively influenced by the application of NPK + PSB and NPK + *Azotobacter*are as follows: Number of nodes to first flowering (25.79), Days to first flowering (85.33), Fruit developmental period (140.25 days), Fruit drop percentage (47.23%), Fruit retention percentage (51.33%), Fruit yield (63.76 kg plant^{-1}), Fruit weight (1460.00 g), Fruit volume (1385.00 cc), Pulp percentage (86.66%), Peel percentage (9.78%), Total Soluble Solids (TSS) (14.00 °Brix), Total sugar content (11.56%) and Titratable acidity content (0.101%).

Singh and Tripathi (2020) discovered that plant spread ranged from 189.15 cm to 191.08 cm north to south and 173.86 cm to 182.22 cm east to west. Fruiting heights ranged from 35.92 cm to 46.12 cm, while leaf count varied between 25.65 and 36.52. Biomass production ranged from 11.65 kg to 29.00 kg. The fruiting developmental period spanned 140.25 to 164.00 days. Flower production ranged from 72.24 to 104.80 and fruit set varied from 22.80 to 43.00 per plant. Maximum fruit yields ranged from 60.44 kg to 67.08 kg, with minimum yields between 22.34 kg and 23.49 kg.

Kanwar *et al.* (2020) conducted a study on Papaya fruit cv. Red Lady and recognised that it had the greatest fruit number (78.33), yield (71.32 kg/plant), fruit weight (1486 g) and length (22.66 cm) among all the treatments. The red lady was undergoing treatment T_8, consisting of 75% of the recommended dose of fertilizer (RDF), 100.00g of *Azotobacter*, 100.00g of PSB and 10 kilograms of vermicompost per plant. This treatment was closely followed by T_9 and T_7 treatments. The number of fruits produced in T_9 and T_7 were 74.33 and 71.00 respectively. The fruit yield in T_9 and T_7 were 67.86 kg and 66.93 kg, respectively. The lengths of the fruits in T_9 and T_7 were 19.33 and 21.33, respectively. The fruit weights in T_9 and T_7 were 1423.33 grams and 1340.00 grams respectively. In contrast, T0 (RDF + Control) had a lower number of fruits and yield.

Singh and Varu (2013) pinpointed that in the papaya cv. Madhu Bindu, the treatment consisting of half the recommended dose of fertilizer (N 100.00g + P 100.00g + K 125 g /plant) + PSB 2.5g /m^2 + *Azotobacter* 50 g/plant (T_8) resulted in increased yield and growth parameters, along with the highest survival rate (98.67 per cent), fruit length (30 cm), weight (1670 g), girth (22 cm), number of fruits (45.33) and yield per plant, hectare, or plot (78 kg/313 kg/259.97 t, respectively). In the same application, the quality variables such as TSS (Total Soluble Solids), total sugars, reducing sugars and non-reducing sugars were seen to be at their highest levels, measuring 15.47 °Brix, 13.58 %, 11.10 % and 2.43 % correspondingly. However, it was discovered that it is equal to a combination of 1/4 recommended dose of fertilizer (RDF) and 3/4 Jivamrut (T13). Control has also exhibited a decrease in output across all metrics.

Singh *et al.* (2008) ascertained that in the papaya cv. Surya, the highest leaf numbers (18.73), stem girth (0.26 m), average weight (0.85 kg), number of fruits (46), thickness of pulp (3.5 cm), TSS (15.8 °B), Vit. A (2280 IU per 100-gram pulp) and shelf life (12 days) were achieved with a treatment consisting of 75% RDF + bacteria culture of rhizosphere + 25% vermicompost. On the other hand, the mean height of the plant (185.35 cm) and the length of the petiole (8.42 cm) were observed under the treatment of 100% RDF alone. The combination of 75% RDF (Recommended Dose Fertilizer) and a bacterium culture of the rhizosphere, along with 25% vermicompost, was found to be superior and economically viable compared to other treatments.

Tandel *et al.* (2014) foundthat in Papaya cv. Red Lady, the T6 treatment, which consisted of 50% RDN from inorganic fertilizer and 25% RDN from a combination of bio compost and castor cake, resulted in higher growth metrics. These included a plant height of 185.39 cm, stem girth of 50.51 cm and leaf number of 44.92. This therapy also impacted other physiological measures, including the photosynthetic rate, transpiration rate, total chlorophyll content and leaf temperature.

Singh and Tripathi (2020) determined the effects of several fertilizer treatments on plant growth, flowering, fruit production, yield and quality to maximise performance. The treatment that consisted of 75% RDF (Recommended Dose of Fertilizer), 100.00g of *Azotobacter*, 100.00g of PSB (Phosphate Solubilising Bacteria) and 2 kg of vermicompost per plant had the maximum effectiveness. It resulted in the greatest biomass, flower and fruit set and overall fruit production while shortening the time required for flowering. This treatment resulted in fruits that exhibited the highest measurements in length, width, weight, TSS (Total Soluble Solids) and total sugar content while simultaneously displaying the lowest titratable acidity levels. Conversely, plants that were not fertilised displayed the smallest and lowest-quality fruits, accompanied by the highest titratable acidity during the entire duration of the trial.

Kinnow (*Citrus reticulata* × *Citrus sinensis*)

Bakshi *et al.* (2018) demonstrated that the treatment of 100% N as urea + *Azotobacter*, along with prescribed MOP and SSP, resulted in the maximum plant height (14.30%), canopy volume (38.95%) and plant spreading direction (E-W 14.0% and N-S 14.05%) in Kinnow Mandarin. The higher yield was obtained by applying N 50% through poultry manure or 50% remaining N through urea in conjunction with *Azotobacter*, with contributing factors such as fruit width (6.53 cm), length (5.84 cm), number of fruits (165.5), fruit volume (191.83 cc), fruit weight (188.18 g) and kinnow fruit yield (31.14 kg) per plant. The study determined that replacing the application of 50% nitrogen in the form of urea with the application of poultry manure, together with *Azotobacter* treatment, is a viable alternative.

Acid lime (*Citrus aurantifolia*)

Kumar *et al.* (2020) originated from their study that Acid Lime had the highest fruit length (5.27 cm), diameter (4.93 cm), number of seeds (8.17), seed weight (1.24 g), juice percentage (56.94%), specific gravity (1.36), peel thickness (1.94 mm), moisture content of peel (84.28 %) and moisture content of pulp (93.89 %) under treatment T_{12}-50% RDF + 75% FYM + 75% Vermicompost + Biofertilizers (25g *Azotobacter* + 25g PSB + 150g VAM). The control group yielded the lowest results.

In their study, Lal and Dayal (2014) reported that the treatment T_6, which consisted of a 50% recommended dose of fertilizer (RDF) and 50% goat manure, resulted in the highest yield (7.58 kg/tree) and the best fruit growth. The fruits treated with T6 had the most extended length (4.43 cm), heaviest weight (35.71 g) and largest diameter (3.99 cm) compared to the other treatments. Similarly, the approach also resulted in the highest TSS (10.42 %), juice yield (43.37 %) and ascorbic acid content (86.33 mg per 100-gram juice), along with a lower number of seeds (1.15 %) and acidity content (6.06 %).

Lemon (*Citrus limon*)

Ghosh *et al.* (2020) disclosed that Lemon cv. Assam Lemon plants had the highest number of flowers per plant (399, 371.67 and 250.33) in the N_4 treatment, which consisted of 75% of the recommended dose of fertilizer (RDF) along with VAM, *Azotobacter* and Vermicompost. On the other hand, the lowest number of flowers (360, 386.33 and 224.33) was observed in the Vermicompost treatment (N_3) during the *Mrig, Ambe* and *Hasth* bahar seasons, respectively. The involvement of bio-fertilizers in nitrogen fixation from the atmosphere and VAM in phosphorus solubilisation is responsible for maintaining a healthy environment or soil, which is ultimately reflected in the flowering of trees. The treatment with N4 resulted in the maximum fruit yield, with 7.67 kg, 13.83 kg and 2.14 kg per plant.

In their study, Mahakulkar *et al.* (2016) detected that Rough Lemon Fruits treated with T8 [75% RDF (450 g N + 225 g P_2O_5 + 225 g K_2O/plant) + 500 g AM (*Actinomycetes*)/plant + 100.00g *Azotobacter*/plant + 100.00g PSB/plant + 15 kg vermicompost/plant] exhibited improved fruit volume (150.95 cc), fruit diameter (8.00 cm), seed germination (68.21 %) and seed vigour (1273.35). However, the TSS and acidity of the fruits did not show any significant differences across the different treatment combinations.

Kumar *et al.* (2018) conceivedthat applying 75% NPK (315g N + 210g P + 315g K) +10kg NC + 200g PSB + 200g *Azotobacter* to Lemon fruit had a statistically significant and beneficial effect. This treatment resulted in the highest increase in tree height (14.44 % and 15.34 %), tree spread (16.20 % and 17.68 %), trunk diameter (11.21 % and 13.55 %), fruit set (79.19 % and 80.54 %) and fruit retention. The control treatment had the highest fruit drop (64.34 % and 63.35 %) during 2011-12 and 2012-13, respectively.

Guava (*Psidium guajava*)

Kumar *et al.* (2014) evaluated the effects of 75% RDF of NPK combined with 200 g each of *Azotobacter*, *Azospirillum* and PSB on guava (*P. guavajava*). This treatment yielded optimal results, with maximum fruit set (52.46%), retention (57.50%) and yield (26.82 kg/plant), alongside improved fruit size and quality, including high TSS (11.82° Brix), total sugars (10.76%) and low acidity (0.23%). These findings suggest that this nutrient management approach effectively enhances guava yield and quality during the winter season in northern India.

In their study, Dhewareet *al.* (2020) diagnosed that the treatment T_4, which consisted of 250 g of PSB, 30 kg of vermicompost and 250 g of *Azospirillum*, resulted in the highest flowering rate (92.33%) and the highest total soluble solids (10.37 °Brix) in Guava Fruit cv. Allahabad Safeda. On the other hand, the treatment T6, which involved the application of 30 kg of vermicompost, 250 g of PSB, 250 g of *Azospirillum* and a foliar spray of vermi wash (diluted with water at a ratio of 1:1), led to the maximum average weight of fruits (400 g), fruit yield (29.60 kg/tree and 11.84 t/ha) and the lowest acidity content (0.19%).

According to Sharma *et al.* (2013), the study verified that guava's quality and yield could be improved by using a treatment containing 75% nitrogen from inorganic sources and 25% nitrogen from FYM (farmyard manure). Another treatment with 50 % nitrogen from inorganic sources 50% nitrogen from FYM and*Azotobacter* also showed positive results. These treatments resulted in the highest levels of total sugars (8.61%) or TSS (12.95 °B) and the lowest physiological weight loss (14.29 %) over ten days under suitable conditions.

Binepal *et al.* (2013) concluded that the treatment T_9 (100%N + P2O5 100% + PSB + *Azospirillum* + Vermicompost 10 kg) resulted in significantly larger Guava fruit with a maximum length of 7.52 cm, diameter of 7.91 cm, volume of 217.41 ml, thickness of pulp of 2.46 cm and weight of pulp of 211.61 g. The treatment also led to a higher weight of seed at 8.76 g. On the other hand, the treatment T10 (75% N + 75% P2O5 + PSB + *Azospirillum* + Vermicompost 10 kg) resulted in a lower percentage of pulp at 96.08 %, which was still higher than the control.

In a study by Goswami *et al.* (2012), the effects of fertilizer-enriched FYM mixed with half the recommended fertilizer dose on five-year-old guava cv. Pant Prabhat plants were evaluated from 2007 to 2009. Utilising a Randomized Block Design with 11 treatments, the research found that applying a half dose of fertilizers (225 g N, 195 g P, 150 g K) along with 50 kg of FYM and 250 g of *Azospirillum* per tree annually significantly enhanced vegetative growth and increased leaf nitrogen (N) and potassium (K) content. The combination of half the prescribed fertilizers, 50 kg of FYM and 250 g each of Trichoderma and Pseudomonas fluorescens resulted in the highest leaf phosphorus content. These findings highlight the effectiveness of integrating biofertilizer-enriched FYM with reduced chemical fertilizers to produce high-quality guava fruits.

According to Shukla *et al.* (2009), the treatment of NPK 50% + 250 g *Azotobacter* + 50 kg FYM (T7) significantly increases the size of the canopy (201.42 m^3), the amount of ascorbic acid in the pulp (198.30 mg per 100.00gram), the weight of the fruit (153.30 g), the total sugar content (8.10 %), the reducing sugar content (4.77%), the TSS (14%) and the nitrogen, phosphorus and potassium content in the leaves (1.40%, 0.46%, 1.17%, respectively) of Guava cv. Sardar. Applying a mixture containing 50% NPK, 250 grams of *Azotobacter* and 50 kilograms of FYM (T_7) resulted in a significantly increased yield of 28.95 kg and the highest B: C ratio of 2.53:1.

In their study, Pilania *et al.* (2010) traced the pruning effect achieved through the application of 50g N + 20g P + 50g K + *Aspergillus niger* + *Azotobacter* + 5 kg vermicompost + 25% pruning intensity (F5 I1), resulted in the highest number of flowers per shoot (57.83) and canopy volume (0.96 m3). On the other hand, the application of 50g N + 20g P + 50g K + *Aspergillus niger* + *Azotobacter* + 5 kg vermicompost + 75% pruning intensity (F5 I3) led to the maximum diameter of fruit (5.31 cm), fruit weight (158.06 g), pulp seed ratio (39.93) and pulp weight (154.19 g) in both years of the study. The highest area of the leaf (59.46 cm^2) and yield (6.68 kg/plant and 33.43 t/ha) are achieved with a combination of 50g N + 20g P + 50g K + Aspergillus niger + *Azotobacter* + 5 kg vermicompost + pruning intensity of 50% (F5 I2), resulting in a B: C ratio of 4.33.

Jamwal *et al.* (2018) comprehended that the application of *Azotobacter* + (100% Nitrogen through urea) T11 resulted in the highest tree height (21.99 %), canopy spread in the north-south direction (23.57%) and canopy spread in the east-west direction (23.50 %) for Guava fruit. Treatment T14, which involved *Azotobacter* + (75% Nitrogen through urea + Vermicompost 25%), resulted in the highest number of fruits per tree (21), average fruit weight (190.10 gm), fruit length (7.10 cm), fruit diameter (7.15 cm), fruit volume (192.13), yield per tree (3.99 kg) and fruit yield per hectare (199.58 q).

Isabgol (*Plantago ovate* Forsk.)

Tripathi *et al.* (2013) investigated the effects of integrated nutrient management on Isabgol (*Plantago ovata* Forsk.), applying treatments of RDF, vermicompost and*Azotobacter* and pioneered that the combination of vermicompost with 75% of the recommended fertilizer, notably improved plant height, leaf and tiller numbers, spike count and length and seeds per spike, while reducing maturity time to 106.5 and 105 days. This treatment yielded the highest unhusked seed production (10.20 and 10.16 q/ha) and husk yield (2.92 and 2.90 q/ha), showing significant benefits of integrated nutrient application.

Plum (*Prunus domestica*)

Kamatyanatti *et al.* (2019) found that in Plum cv. Kala Amritsari, the treatment T11, which consisted of 75% nitrogen (N), 12.5% N from farmyard manure (FYM), 12.5% N from vermicompost and bio-fertilizers, resulted in the highest per centage increase in plant height (0.27 m). In height (4.91%), leaf area (13.13 cm^2), chlorophyll index (23.88) and annual shoot growth (70.63 cm). Treatment T9, which contained 75% N, bio-fertilizers and 25% N from FYM, also showed significant growth. In contrast, the control treatment (T1) had the lowest plant height of 0.14 m. The highest fruit yield (52.14 kg/tree) was obtained in treatment T11, while the lowest yield (38.63 kg/tree) was recorded in treatment T2, which was 50% nitrogen (N) and 50% nitrogen from farmyard manure (FYM) received.

Litchi (*Litchi chinensis*)

Raghavan *et al.* (2018) distinguished that the Litchi cv. had the highest fruit number (1281), total sugars (26.14 %), yield (30.01 kg) and reducing sugar (14.51 %) per tree. Muzaffarpur was treated with a combination of 500 grams of NPK, consisting of 250 grams of nitrogen, 250 grams of phosphorus and 250 grams of potassium, along with 100.00grams of VAM, 100.00grams of PSM, 150 grams of *Azotobacter* and 100.00 kilograms of FYM (T9). On the other hand, the control group received a higher dosage of NPK, consisting of 1000 grams of nitrogen, 500 grams of phosphorus and 500 grams of potassium, resulting in the highest incidence of fruit cracking. The most effective method for improving fruit yield and quality in litchi was the application of a combination of 500 g of nitrogen (N), 250g of phosphorus (P), 250 g of potassium (K), 100.00g of vesicular-arbuscular mycorrhiza (VAM), 100g of phosphate solubilising microorganisms (PSM), 150 g of *Azotobacter* and100.00kg of farmyard manure (FYM) in the foothills of Arunachal Pradesh.

Kumar (2008) investigated organic nutrient management for Bombai litchi in West Bengal, India, using organic sources (farm yard manure, poultry manure, vermicompost, neem cake) with biofertilizers (e.g., *Azotobacter*, *Azospirillum*, phosphorus solubilisers (PSB), potash mobilisers). Farm yard manure and biofertilizers yielded the highest fruit weight (24.73 g), total soluble solids (17.79 °Brix) and total sugars (17.57%), while vermicompost with bio-fertilizers maximised fruit count (2556) and yield (61.59 kg/tree). Neem cake with bio-fertilizers produced the highest vitamin C content (53.48 mg/100.00g pulp). Vermicompost at 42.86 kg/tree per year with biofertilizers was recommended for optimal litchi production.

Dutta *et al.* (2010) inspected the impact of incorporating organic manures and bio-fertilizers on the litchi cv. Bombai with or without chemical fertilizers. Treatment involving 50 kg of farmyard manure per tree, 150 g of *Azotobacter*, 100.00g of vesicular-arbuscular mycorrhiza (VAM) and 500 g of nitrogen, 250 g of phosphorus pentoxide (P_2O_5) and 500 g of potassium oxide (K_2O) per tree per year resulted in the highest fruit production (98.72 kg per plant). Furthermore, this treatment significantly improved various aspects of fruit quality, such as total soluble solids (TSS), total sugars, ascorbic acid content, TSS to acid ratio, fruit weight and size. The same treatment led to the highest levels of nitrogen (N) and potassium (K) in the leaves, as well as a microbial population of 8.3×10^6 colony-forming units per gram of soil (cfu/g). Although using organic manure and biofertilizers resulted in better fruit quality when compared to using only chemical fertilizers, their effect on productivity was less significant. Applying organic treatments resulted in fruits with the highest concentration of anthocyanins, measuring 22.45 mg per 100.00g of peel.

Sapota (*Manilkara zapota*)

Meena *et al.* (2019) scrutinised 17 integrated nutrient management (INM) combinations on sapota in the Chambal region, India by utilising 2/3 of RDF + 50 kg FYM + 250 g *Azospirillum* + 250 g *Azotobacter* per plant (T_{11}) resulted in the highest fruit yield

(327.88 fruits/plant, 29.03 kg/plant, 4.52 t/ha), with 32% yield increase compared to control. The highest microbial counts were found in 2/3 RDF + 10 kg vermicompost + 250 g *Azospirillum* + 250 g *Azotobacter* (T_{15}), with fungi (8.89 cfu g^{-1}), bacteria (11.19 cfu g^{-1}) and actinomycetes (5.60 cfu g^{-1}). T15 also had the highest leaf nitrogen content (2.03%), while T11 had the highest phosphorus (0.28%) and potassium (1.80%). These findings emphasise the benefits of integrated nutrient management for sapota yield and soil health.

Sheik *et al.* (2019) investigated sapota cv. Kirthabarthi and assessed the impact of integrated nutrient management (INM) on fruit quality. The highest quality was achieved with 12.5 kg vermicompost/tree + RDF (1000 g N, 1000 g P, 1500 g K/tree) + EM (1:250 dilution), showing the highest TSS (19.86°B and 19.80°B), ascorbic acid (2.85 mg/100.00g and 2.69 mg/100.00g), total sugar (18.35% and 18.19%), reducing sugar (13.10% and 13.02%), non-reducing sugar (5.25% and 5.17%) and lowest acidity (0.18% and 0.16%). The control treatment recorded the lowest quality and highest acidity. During peak season, I generally showed higher values.

Tasleema *et al.* (2019) experimented on twenty-year-old sapota trees (cv. Kirthabarthi) planted at 8 m × 8 m spacing, with eight treatments replicated thrice. The treatments included combinations of FYM, vermicompost, RDF and EM inoculation. The results showed that the treatments significantly influenced plant height, spread and canopy volume. The highest plant height (7.29 m), widest plant spread (7.20 m North-South, 7.19 m East-West) and maximum canopy volume (96.49 m^3) were recorded in trees receiving RDF, vermicompost (12.5 kg/tree) and EM.

Phalsa (*Grewia asiatica*)

Sutariya *et al.* (2018) catalogued the quality characteristics of Phalsa cv. Local, specifically juice content (53.07 %), TSS (23.17 °Brix), total sugar (6.55 %), reducing sugar (2.77%) and ascorbic acid (38.20 mg/100.00g of fresh pulp), were significantly higher in the T_7 treatment. The T_7 treatment consisted of 50 % nitrogen applied through urea, 25% nitrogen applied through vermicompost per plant, 100.00g P_2O_5 applied through SSP, 50 g K_2O applied through MOP per plant and the use of AAU PGPR consortium. Additionally, the T_7 treatment showed the lowest acidity level (2.02 %).

Bael (*Aegle marmelos*)

Vishwakarma *et al.* (2017) disentangled that in the Bael cv. Narendra Bael-9, the highest measurements for fruit length (24.00 cm and 24.62 cm), fruit width (18.08 cm and 19.32 cm), fruit weight (2.41kg/fruit and 2.45 kg/fruit), number of seeds per fruit (114.50 and 120.75), minimum shell weight (303.44 g and 306.50 g), maximum TSS (35.66 °Brix and 37.85 °Brix), ascorbic acid content (20.75 mg/100g pulp and 21.26 mg/100g pulp) and total carotene content (55.84 µg/100g pulp and 55.72 µg/100g pulp) were observed when T7-50 Kg FYM + 100% NPK + 200g each (*Azotobacter* + PSB) was applied, followed by the use of T8 75% NPK + 200g PSB + 200g *Azotobacter* + 50 Kg FYM. These results were superior to the other treatments during the two years of the experiment.

Walnut (*Juglans regia*)

Bhattarai and Tomar (2009) reported that applying NPK + 50 kg vermicompost and ¾ NPK + vermicompost 68.75 kg improved walnut leaf nutritional quality.

Pineapple (*Ananas comosus*)

Baraily and Deb (2018) traced in their study, that treatment T_9, which consisted of 75 % RDF of NPK, bio-fertilizer and 7.5 t/ha Vermicompost, resulted in the highest values for fruit length without crown (21.92 cm), crown length (14.91cm), crown weight (170.7 g), estimated yield without crown (63.41t/ha), fruit juice content (0854.8 g), TSS (13.56 ^{0}Brix) and reducing sugar (5.77 %). These results were similar to those obtained with treatment T8, which included 100.00% RDF of NPK, bio-fertilizer and 5 t/ha Vermicompost.

Strawberry (*Fragaria* × *ananassa*)

Kumar and Tripathi(2020) analysed the effect of *Azotobacter*, PSB and vermicompost on the growth, flowering, yield and quality of strawberry (*Fragaria x ananassa* Duch.) cv. Chandler. The application of *Azotobacter* at 7 kg/ha significantly enhanced plant growth, with an increase in plant height (16.25 cm), number of leaves (55.40), crowns (6.60) and runners (5.25) per plant. It also led to the maximum number of flowers (75.45) and fruit set (28.35) per plant, along with a longer harvesting duration (67.90 days). The earliest first flowering (61.85 days) and the highest yield (185.75 g/plant) were observed. The berries showed the most significant length (3.80 cm), width (2.52 cm) and weight (7.40 g), as well as higher TSS (9.21 °Brix), total sugars (8.21%) and ascorbic acid (55.29 mg/100g) with the lowest titratable acidity (0.601%).

Tripathi *et al.* (2016b) assessed the impact of varying levels of *Azotobacter*, *Azospirillum*, PSB and black polythene mulch on strawberry cv's growth, yield and quality. Chandler. Treatments with *Azotobacter* at 7 kg/ha combined with black polythene mulch led to significantly improved plant height (18.70 cm), leaf number (16.75), runner count (2.17) and crown number (2.64) per plant. This treatment also reduced days to first flowering (65.33), increased flower (15.87) and fruit set (14.72) per plant, extended harvest duration (67 days) and enhanced yield (107 g/plant). Quality traits of berries improved, with greater length (2.90 cm), width (1.79 cm), weight (7.11 g), volume (4.36 cc), TSS (7.16 °Brix), total sugars (5.60%), ascorbic acid (56.00 mg/100g) and reduced acidity (0.249%) under North central plain of the Indian subcontinent.

Tripathi *et al.* (2015) investigated the effects of *Azotobacter* and vermicompost on strawberry growth and quality. The study employed nine treatments, including a control with FYM as a basal dose. The highest plant height (18.70 cm), leaf count (61.60), crowns (6.77) and runners (4.83) were observed with *Azotobacter* at 7 kg/ha and vermicompost at 30 t/ha. Meanwhile, *Azotobacter* at 6 kg/ha combined with vermicompost at 30 t/ha resulted in the most flowers (56.69), fruit set (25.87) and prolonged harvesting duration (66.80 days), along with fewer days to first flower (55.17) and fruit set (6.19). This treatment also produced the maximum yield (322.38 g/plant) and berries with optimal measurements: length (4.76 cm), width (2.49 cm), weight (8.75 g), volume (5.97 cc), total soluble solids (9.80 °Brix), total sugars (9.23%) and ascorbic acid (54.72 mg/100.00g), while maintaining the lowest acidity (0.50%) under plains of central Uttar Pradesh.

Tripathi *et al.* (2016a) collected the effects of *Azotobacter*, *Azospirillum* and PSB on strawberry cv. Chandler over two years. The application of *Azotobacter* at 7 kg/ha notably increased plant height (16.05 cm), leaf number (54.75), crown count (6.34), runner production (4.93), flower count (52.38), fruit set (25.66) and yield (180.89 g/plant). Quality characteristics were enhanced as well, with larger berries (3.55 cm length, 2.35 cm width), higher TSS (9.13° Brix), total sugars (8.20%) and ascorbic acid (56.01 mg/100g pulp), highlighting the efficacy of *Azotobacter* at 7 kg/ha for improved strawberry yield and quality.

Chaurasia *et al.* (2022) investigated the impact of several combinations of biofertilizers on the growth, fruit production and features of strawberry (*Fragaria* × *ananassa* Duch.) cv. Winter Dawn in a vertical farming setup. The study employed a total of 10 treatments, including a control group. These treatments consisted of various combinations of organic and microbial sources, such as vermicompost, FYM, *Azotobacter*, *Azospirillum* and PSB. The experiment was performed three times using a Randomized Block Design. The application of Treatment T_9, which consisted of a mixture of 50% soil and 50% vermicompost together with 2g each of *Azotobacter* and *Azospirillum*, resulted in the most significant outcomes regarding plant height, spread, leaf number and area. Additionally, this treatment led to the earliest flowering and the most considerable number of flowers per plant. Additionally, this treatment resulted in the most tremendous fruit weight, quantity of fruits per plant and overall production. It had the highest Benefit: Cost ratio (1:3.39) compared to T_7 (Soil 50% + FYM 50% + PSB 2g + *Azotobacter* 2g) because it had a lower cost of manufacture. Regarding both productivity and fruit quality, T9 demonstrated higher performance overall.

Umar *et al.* (2008) found that the best crop yield of 372.89q per hectare was achieved when entirely nitrogen (N) was applied using urea + *Azotobacter*. The second highest yield of 358.43q per hectare was obtained when 75% of the nitrogen was applied as urea and 25% as FYM (Farm Yard Manure) + *Azotobacter*. These two treatments showed a close relationship in terms of production.

Nazir *et al.* (2015) documented the growth characteristics of a plant, including its maximum height (23.39 cm), number of runners per plant (13.03) and plant spread (24.21 cm). They found that the treatment involving PSB + wood ash + *Azotobacter* + poultry manure + mustard oil cake resulted in the highest yield (238.95 g) and improved physical fruit characteristics, such as diameter (3.11 cm), length (3.95 cm), weight (11.11 g) and volume (20.39 cm^3). Additionally, this treatment had positive effects on chemical characteristics, such as TSS (9.01 °B), total sugars (7.95 %) and acidity (0.857%) content.

Bhagat and Panigrahi (2020) exposed that the flowering and physical characteristics of the fruit were significantly affected by the treatment T11, which included the application of RDF, *Azospirillum*, Phosphate Solubilizing Bacteria and VAM. The observed values for the number of flowers, number of fruits, diameter, length, volume, weight of fruit and fruit yield were 43.41, 41.80/plant, 4.85 cm, 6.64 cm, 37.17 cc, 43.33 g and 355.84 q/ha, respectively. On the other hand, the control treatment (T0) resulted in the lowest values for these parameters. Furthermore, the treatment with the highest benefit-cost ratio was the same as the one mentioned earlier, with a ratio of 4.20:1. Conversely, the treatment with the lowest value of 2.20:1 was observed in the RDF + control treatment.

Anushi *et al.* (2024) investigated the effects of bio-stimulants and organic mulch on soil microbes in strawberry cv. Katrain Sweet. The treatment combining *Azotobacter*, *Trichoderma harzianum*, PSB and dried leaves significantly boosted bacterial (8.97×10^5 cfu g^{-1}) and fungal (5.93×10^3 cfu g^{-1}) populations, surpassing the control. These results highlight the potential of bio-stimulants and organic mulch in enhancing soil microbial activity for sustainable strawberry production.

Conclusion

Inconsistent and unbalanced use of chemical fertilizers negatively affects soil productivity and crop yield, leading to stagnation or loss of crop production. To maximize yield capacity, optimizing fertilizers usage is essential. The use of chemical fertilization has undeniably led to an increase in crop production. However, there is also has the potential to cause soil erosion and soil health problems. On the other hand, the exclusive use of organic fertilizer without the addition of inorganic fertilizers may not able to meet the nutrient requirements of high-demand crops because these organic fertilizers are present in large quantities and are release. The use of cost-effective and environmentally friendly bio-fertilizers promises an enormous increase in crop yields in modern agriculture. However, it is extremely difficult to effectively cover all nutrient requirements through the use of organic fertilizers and bio- fertilizers. Therefore, based on the study, as already mentioned, it is recommended to provide 50% of the necessary nutrients through inorganic fertilizers and the rest be obtained from organic sources. The integrated nutrition management strategy can increase crop yield through synergy effects and contribute to maintaining soil conditions.

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References

Acevedo, I. C. and Pire, R. (2004). Effects of vermicompost as substrate amendment on the growth of papaya (*Carica papaya* L.). *Interciencia*, **29**(5), 274-279.https://doi.org/10.15316 / S JAFS.2018.143

Anushi, Tripathi, V. K., Tripathi, V. K., & Shukla, P. (2024). Influence of biostimulants and organic mulch on soil microbial population in strawberry (*F.* × *ananassa* Dutch.). *Biochemical and Cellular Archives,* *24*(2), 2551-2555. https://doi.org/10.51470/bca.2024.24.2.2551

Alam, S. and Seth, R. K. (2014). Comparative study on effect of chemical and biofertilizer on growth, development and yield production of paddy crop (*Oryza sativa*). *International Journal of Science and Research*, 3(9), 411-414. Corpus ID: 29527241

Athani, S. I. and Hulamani, N. C. (2000). Effect of vermicompost on fruit yield and quality of banana cv. Rajapuri (*Musa* AAB). *Karnataka Journal of Agricultural Sciences*, 13(4), 942-946.

Athani, S. I., Ustad, A. I., Prabhuraj, H. S., Swamy, G. S. K., Patil, P. B. and Kotikal, Y. K. (2005). Influence of vermicompost on growth, fruit yield and quality of guava cv. Sardar. In 1st *International Guava Symposium*, 735:381-385. 10.17660/ActaHortic.2007.735.54

Bakshi, M., Wali, V. K. and Sharma, D. (2018). Growth, yield and quality of Kinnow mandarin as affected by integrated nutrient management. *Annals of Biology*, 34(2), 202-206.

Baraily, P. and Deb, P. (2018). Influence of integrated nutrient management on yield and bio-chemical parameters of pineapple cv. Kew. *Journal of Pharmacognosy and Phytochemistry*, 7(5), 1339-1342.

Baskar, K., Gabhane, V. V., De, N., Vasanthi, B. G., Kundu, S., Sanjiv Kumar, V., Kumara, B. H., Ramesha, M. N., Manikandan, M., & Sharma, R. (2022). Integrated nutrient management practice for rainfed crops. *Indian Farming*, 72(08), 46–49.

Bhagat, P. and Panigrahi, H. (2020). Effect of biofertilizers on growth, yield and quality of strawberry (*Fragaria x ananassa* Duch.) cv. Nabila under net tunnel (Doctoral dissertation, Indira Gandhi Krishi Vishwavidyalaya, Raipur).

Bhalerao, V. P., Patil, N. M., Badgujar, C. 3D. and Patil, D. R. (2009). Studies on integrated nutrient management for tissue cultured Grand Naine banana. *Indian Journal of Agricultural Research*, 43(2), 107-112.

Bhattarai, B. P. and Tomar, C. S. (2009). Effect of integrated nutrient management on leaf nutrient status of walnut (*Juglans regia* L.). *Nepal Journal of Science and Technology*, 10, 63-67. https://doi.org/10.3126/njst.v10i0.2825.

Binepal, M. K., Tiwari, R. and Kumawat, B. R. (2013). Effect of integrated nutrient management on physico-chemical parameters of guava under Malwa Plateau conditions of Madhya Pradesh. *Annals of Plant and Soil Research*, 15(1), 47-49.

Chaurasia, J., Mishra, S. and Singh, R. K. (2022). Development, Fruit setting and Pomological characteristics in Strawberry (*Fragaria ananassa* Duch.) as affected by Biofertilizers under vertical farming system. cv. Winter dawn. *International Journal of Environment and Climate Change*, 1168–1176. https://doi.org/10.9734/3IJECC/2022/V12I1030913

Dutta, P., Kundu, Subhasis and Biswas, S. (2010). Integrated nutrient management in litchi cv Bombai in new alluvial zone of West Bengal. *Indian Journal of Horticulture*, 67, 181-184.

Gajbhiye, B. R., Patil, V. D. and Kachave, T. R. (2020). Effect of integrated nutrient management on growth and yield of pomegranate (*Punica granatum* L.). *Journal of Pharmacognosy and Phytochemistry*, 9(4), 1703-1706.

Gaur, A. C. (2001). Organic manure: A basic input in organic farming. *Indian Farming*, 51(3), 3-11.

Gautam, U. S., Singh, R., Tiwari, N., Gurjar, P. S. and Kumar, A. (2012). Effect of integrated nutrient management in mango cv. Sunderja. *Indian Journal of Horticulture*, 69(2), 151-155.

Ghosh, A., Dey, K., Bhowmick, N. and Dey, A. N. (2020). Reproductive Behaviour of Lemon (*Citrus limon* Burm.) Affected by Different Pruning Intensities and Integrated Nutrient Management Under Various Growing Seasons. *National Academy Science Letters*, 43(1), 81-84. http://dx.doi.org/10.20546/ijcmas.2017.604.073.

Goswami, A. K., Lal, S. and Misra, K. (2012). Integrated nutrient management improves growth and leaf nutrient status of guava cv. Pant Prabhat. *Indian Journal of Horticulture*, *69*(02), 168–172. https://journal.iahs.org.in/index.php/ijh/article/view/1968

Hasan, M. A., Manna, M., Dutta, P., Bhattacharaya, K., Mandal, S., Banerjee, H. and Jha, S. (2013). Integrated nutrient management in improving fruit quality of mango 'Himsagar'. *Acta Horticulturae*, (992), 167-172.

Jamwal, S., Mishra, S. and Singh, S. (2018). Effect of integrated nutrient management on physical characteristics of Guava under Meadow Orcharding cv. Allahabad Safeda. *Journal of Pharmacognosy and Phytochemistry*, 2076-2079.

Jat, L. K., Singh, Y. V., Meena, S. K., Meena, S. K., Parihar, M., Jatav, H. S. and Meena, V. S. (2015). Does integrated nutrient management enhance agricultural productivity. *J. Pure Appl. Microbiol.*, 9(2), 1211-1221.

Kamatyanatti, M., Kumar, A. and Dalal, R. P. S. (2019). Effect of integrated nutrient management on growth, flowering and yield of subtropical plum cv. Kala Amritsari. *Journal of Pharmacognosy*. 8(1), 1904-1908.

Kanwar, A., Sahu, G. D. and Panigrahi, H. K. (2020). Impact of integrated nutrient management on yield and quality parameters of papaya (*Carica papaya* L.) Cv. Red Lady under net house. *Journal of Pharmacognosy and Phytochemistry*, 9(3), 1443-1445.

Katiyar, P. N., Tripathi, V. K., Sachan, R. K., Singh, J. and Chandra, Ram. (2012). Integrated nutritional management affects the growth, flowering and fruiting of rejuvenated Ber. *HortFlora Research Spectrum*. 1. 38-41.

Katyal, J.C., Chaudhari, S.K., Dwivedi, B.S., Biswas, D.R., Rattan, R.K. and Majumdar, K. (2016). Soil Health: Concept, Status and Monitoring. *Bulletin of the Indian Society of Soil Science*, 30, 1-98.

Kumar S., Reddy C., Phogat M. and Korav S. (2018). Role of bio-fertilizers towards sustainable agricultural development: A review. *J. Pharm. Phytochem.,* 7:1915–1921.

Kumar S., Tripathi, V. K., Awasthi, M. and Tiwari, S. (2023). Influence of Integrated Nutrient Management on Growth, Yield and Quality of aonla cv. Na-7. Recent Development in Agriculture, *Prog. Agric*., 23 (2): 222-227. http://dx.doi.org/10.5958/0976-4615.2023.00031.5

Kumar, A., and Tripathi, V. K. (2020). Effect of *Azotobacter*, PSB and vermicompost on growth, flowering, yield and quality of strawberry (*Fragaria x ananassa* Duch.) cv. Chandler. Progressive Horticulture, 52(2). https://doi.org/10.5958/2249-5258.2020.00022.6

Kumar, R. (2008). Evaluation of Dynamic Substrates under Integrated Plant Nutrient Management Affecting Growth Yield and Quality of Litchi (*Litchi chinensis* Sonn.). In III International Symposium on Longan, Lychee and other Fruit Trees in Sapindaceae Family 863 (pp. 243-248). https://doi.org/10.17660/ActaHortic.2010.863.31

Kumar, S., Kundu, M. and Rakshit, R. (2019). Effect of bio-fertilizer on growth, yield and quality of strawberry (*Fragaria× ananassa* Duch.) cv. Camarosa. *Bull. Env. Pharmacol. Life Sci*., 8, S99-S107.

Kumar, T. B., Kumar, G. P., Kumar, R. S. and Muruganandam, C. (2020). Effect of nutrient management through bio-organic manures on fruit setting, fruit drop and fruit retention of acid lime (*Citrus aurantifolia* Swingle). Plant Archives, 20(1), 1570-1572.

Kumar, V., Malik, S., Dev, P., Kumar, M., Singh, M. and Mohan, B. (2018). Effect of integrated nutrient management in relation to vegetative parameters of lemon (*Citrus limon*burm) cv. pant Lemon-1 in sandy loam soil under Western Uttar Pradesh

Conditions. *Progressive Agriculture*, 18(2), 236-239. 10.5958/0976-4615.2018.00042.X.

Kumara A., Sharma, D.D., Sharma, D.P., Shylla, B., Singh, U., Verma, P., Mushtaq, M., Singh Parihar, N.S., Wanie, O. A., Casini, R., Almutairis, K. F. and Elansary, H.O. (2024). Integrated Nutrient Management as a Low Cost and Eco-Friendly Strategy for Sustainable Fruit Production in Apricot (*Prunus armeniaca* L.). *International Journal of Fruit Science*, 24 (1), 18-32. https://doi.org/10.1080/15538362.2023.2273356

Kuttimani, R., Velayudham, K., Somasundaram, E. and Jothi, N. J. (2013). Effect of integrated nutrient management on corm and root growth and physiological parameters of banana. *Int. J. Adv. Res*, 1, 46-55.

Lal, G. and Dayal, H. (2014). Effect of integrated nutrient management on yield and quality of acid lime (*Citrus aurantifolia* Swingle). African Journal of Agricultural Research, 9(40), 2985-2991. https://doi.org/10.5897/AJAR2014.8902.

Mahajan, A. and Gupta, R.D. (2009). Components of INM System. In: (eds) Integrated Nutrient Management (INM) in a Sustainable Rice—Wheat Cropping System. *Springer*, Dordrecht. https://doi.org/10.1007/978-1-4020-9875-8_4

Mahakulkar, R. N., Joshi, P. S., Satkar, K. and Daberao, M. (2016). Effect of integrated nutrient management on seed germination and fruit quality of rough lemon. *Current Advances in Agricultural Sciences* (*An International Journal*),8(1),112-113.https://doi.Org/10.20546 /ijcmas. 2020.910.269

Mahmud, M., Ramasamy, S., Othman, R., Abdullah, R. and Yaacob, J. S. (2019). Effect of Vermicompost Application on Bioactive Properties and Antioxidant Potential of MD2 Pineapple Fruits. *Agronomy*, 9(2), 97. https://doi.org/10.3390/agronomy9020097.

Meena, H. R., Somasundaram, J., Kaushik, R. A., Sarolia, D. K., Singh, R. K. and Meena, G. L. (2019). Integrated Nutrient Management Affects Fruit Yield of Sapota (*Achras zapota* L.) and Nutrient Availability in a Vertisol. Communications in Soil Science and Plant Analysis, 50(22), 2848-2863. https://doi.org/10.1080/00103624.2019.1689248

Nayyer, M. A., Tripathi, V. K., Kumar, S., Lal, D. and Tiwari, B. (2014). Influence of Integrated Nutrient Management on growth, yield and quality of tissue cultured banana (*Musa× paradisiaca)* cv Grand Naine. *Indian Journal of Agricultural Sciences*, 84(6), 680-683.

Nazir, N., Kumar, A., Khalil, A. and Bandey, S. A. (2015). Effect of integrated organic nutrient management on fruit yield and quality of strawberry cv Senga Sengana. *International Journal of Farm Sciences*, 5(2), 83-89.

Nehete, D. S. and Jadav, R. G. (2019). Effect of bio-fertilizers in combination with chemical fertilizers on flowering, yield and quality of mango (*Mangifera indica* L.) cv. Amrapali. *Journal of Pharmacognosy and Phytochemistry*, 8(4), 2934-2938.

Patil, V. K. and Shinde, B. N. (2013). Studies on integrated nutrient management on growth and yield of banana cv. Ardhapuri (*Musa* AAA). *Journal of Horticulture and Forestry*, 5(9), 130-138. 10.5897/JHF2013.0314.

Pilania, S., Shukla, A. K., Mahawer, L. N., Sharma, R. and Bairwa, H. L. (2010). Standardisation of pruning intensity and integrated nutrient management in meadow orcharding of guava (*Psidium guajava*). *Indian Journal of Agricultural Sciences*, 80(8), 673.

Poonia, K. D., Bhatnagar, P., Sharma, M. K. and Singh, J. (2018). Efficacy of biofertilizers on growth and development of mango plants cv. Dashehari. *J. Pharmac. and Phytochem*, 7(5), 2158-2162.

Raghavan, M., Hazarika, B. N., Das, S., Ramjan, M. and Langstieh, L. B. (2018). Integrated nutrient management in litchi (*Litchi chinensis* Sonn.) cv. Muzaffarpur for yield and fruit quality at foothills of Arunachal Pradesh. *IJCS*, 6(3), 2809-2812.

Rai, K. M. (2014). Studies on integrated nutrient management in mango (*Mangifera indica* L.) cv. Dashehari (Doctoral dissertation, GB Pant University of Agriculture and Technology, Pantnagar-263145 (Uttarakhand).

Saikia, P., Bhattacharya, S. S. and Baruah, K. K. (2015). Organic substitution in fertilizer schedule: Impacts on soil health, photosynthetic efficiency, yield and assimilation in wheat grown in alluvial soil. *Agriculture, Ecosystems and Environment*, 203, 102-109.

Sharma, A., Wali, V. K., Bakshi, P. and Jasrotia, A. (2013). Effect of integrated nutrient management strategies on nutrient status, yield and quality of guava. *Indian Journal of Horticulture*, 70(3), 333-339.

Sharma, R., Jain, P. K. and Sharma, T. R. (2016). Improvement in productivities and profitability in high-density orchard of mango (*Mangifera indica* L) cv. Amrapali through integrated nutrient. *Economic Affairs*, 61(3), 533-538.

Sheik, R. T., Kamalakannan, S., Rajeswari, R. and Sudhagar, R. (2019). Effect of integrated nutrient management on fruit quality in sapota (*Manilkara zapota* (L.) P. Royen. *Annals of Plant and Soil Research*, 21(1), 67-70.

Shukla, A. K., Sarolia, D. K., Kumari, B., Kaushik, R. A., Mahawer, L. N. and Bairwa, H. L. (2009). Evaluation of substrate dynamics for integrated nutrient management under high-density planting of guava cv. Sardar. *Indian Journal of Horticulture*, 66(4), 461-464.

Shukla, A., Dwivedi, A. K., Tripathi, V. K., Singh, R. S., Kumar, M. and Shukla, J. K. (2022). Effect of INM on growth parameters of tissue cultured banana cv. Grand Naine under North Indian condition. *The Pharma Innovation Journal*, 11(4), 1337-1339.

Singh, A. and Tripathi V.K. (2020). Influence of Integrated Nutrient Management on Flowering, Fruiting, Yield and Quality Parameters of Papaya (*Carica papaya* L.). *International Journal of Agriculture Sciences,* 12 (18), 10194-10197.

Singh, A. and Tripathi, V. K. (2020). Influence of INM on vegetative growth, fruiting, yield and soil physical characters in papaya (*Carica papaya* L.). *International Journal of Current Microbiology and Applied Sciences*, 9(10), 3811-3822. https://doi.org/10.20546/ijcmas.2020.910.438.

Singh, J. K. and Varu, D. K. (2013). Effect of integrated nutrient management in papaya (*Carica papaya* L.) cv. Madhubindu. *Asian Journal of Horticulture*, 8(2), 667-670.

Singh, K., Barche, S. and Singh, D. B. (2008). Integrated nutrient management in papaya (*Carica papaya* L.) cv. Surya. In II International Symposium on Papaya 851. 377-380. 10.17660/ActaHortic.2010.851.57.

Singh, R., Sharma, R. R., Kumar, S., Gupta, R. K. and Patil, R. T. (2008). Vermicompost substitution influences growth, physiological disorders, fruit yield and quality of strawberry (*Fragaria x ananassa* Duch.). *Bioresource Technology*, 99(17), 8507-8511.https://doi.org/10.1016/j.biortech. 2008.03.034

Singh, S. R., Banik, B. C. and Hasan, M. A. (2015). Effect of integrated nutrient management on vegetative growth and yield in mango cv. Himsagar. *Journal of Horticultural Sciences*, 10(1), 120-124. https://doi.org/10.24154/jhs.v10i1.176.

Solanki, S. P. S., Sharma, N. C., Chandel, J. S. and Hota, D. (2020). Effect of Integrated Nutrient Management on Fruit Yield and Quality of Peach (*Prunus persica* L. Batsch) cv. July Elberta. *International Research Journal of Pure and Applied Chemistry*, 152-160. https://doi.Org/10.2415 4 /jhs.v10i1.176.

Stewart, W. and Roberts T. (2012). Food security and the role of fertilizer in supporting it. *Procedia Eng*. 46:76–82. https://doi.org/10.1016/j.proeng.2012.09.448.

Sutariya, N. K., Patel, M. J., Patel, H. A. and Vasara, R. P. (2018). Effect of integrated nutrient management on bio chemical parameters of phalsa (*Grewia subinaequalis* L.) cv. Local. *Journal of Pharmacognosy and Phytochemistry*, 7(5), 408-411.

Talang, H. D., Dutta, P., Mukhim, C. and Patil, S. (2017). Effect of integrated nutrient management on mango (*Mangifera indica* L.) cv. Himsagar. *Journal of Horticultural Sciences*, 12(1), 23-32.

Tandel, B. M., Patel, B. N. and Patel, B. B. (2014). Effect of Integrated Nutrient Management on Growth and Physiological Parameters on Papaya cv. Taiwan Red Lady. *Trends in Biosciences*, 7(16), 2175- 2178.

Tasleema, S. R., Kamalakannan, S., Rajeswari, R. and Sudhagar, R. (2019). Effect of integrated nutrient management on growth characters in sapota. *Plant Archives*, 19(1), 1086-1088.

Tripathi, V. K. (2017). Influence of integrated nutrient management in ratoon crop of tissue cultured banana. *Progressive Research–An International Journal Society for Scientific Development in Agriculture and Technology*, 12(Special-IV), 2577-2580.

Tripathi, V. K., Bahadur S., Kumar, A. (2015a). Influence of Integrated Nutrient Management on Yield and Physico-Chemical Parameters of Aonla cv. NA-7. *Progressive Research – An International Journal*, 10 (VI): 3493-3496. 10.13140/RG.2.2.34232.37129

Tripathi, V. K., Jain, A., Dubey, V., Kumar, A. and Pandey, H. (2016b). Effect of different levels of *Azotobacter*, *Azospirillum*, PSB and black polythene mulch on growth, yield and quality of strawberry cv. Chandler. *Progressive Research – An International Journal Society for Scientific Development in Agriculture and Technology, 11*(Special-VIII), 5185-5188.

Tripathi, V. K., Kumar, S. and Gupta, A. K. (2015). Influence of *Azotobacter* and vermicompost on growth, flowering, yield and quality of strawberry cv. Chandler. *Indian Journal of Horticulture*, 72(2), 201-205. https://doi.org/10.5958/0974-0112.2015.00039.0

Tripathi, V. K., Kumar, S., Katiyar, P. N. and Nayyer, A. (2013). Integrated nutrient management in Isabgol (*Plantago ovata*Forsk.). *Progressive Horticulture*, 45(2), 302-305. http://dx.doi.org/10.13 140/RG.2.2.20810.59849.

Tripathi, V. K., Shyam, B., Dubey, V. and Kumar, A. (2015b). Influence of integrated nutrient management on yield and physicochemical parameters of aonla cv. NA-7. *Progressive Research – An International Journal*, 10(6), 3493-3496. 10.13140/RG.2.2.34232.37129.

Turyasingura, B., Akatwijuka, R., Tumwesigye, W., Ayiga, N., Ruhiiga, T. M., Banerjee, A., Benzougagh, B., & Frolov, D. (2023). Progressive efforts in the implementation of integrated water resources management (IWRM) in Uganda. In *Disaster Risk Reduction in Agriculture* (pp. 543–558). Springer. https://doi.org/10.1007/978-981-99-1763-1_26

Umar, I., Wali, V. K., Kher, R. and Sharma, A. (2008). Impact of integrated nutrient management on strawberry yield and soil nutrient status. *Applied Biological Research*, 10(1 & 2), 22-25.

Vala, G. S., Dodiya, V. C., Mandaviya, T. K. and Bambhaniya, V. S. (2020). Influence of Integrated Nutrient Management on Various Growth Attributes and Yield of Mango (*Magnifera indica* L.) cv. Jamadar. *Int. J. Curr. Microbiol. App. Sci*., 9(06): 1591-1596. https://doi.org/10.20546/ ijcmas .2020.906.196

Vishwakarma, G., Yadav, A. L., Kumar, A., Singh, A. and Kumar, S. (2017). Effect of Integrated Nutrient Management on Physico-Chemical Characters of Bael (*Aegle marmelos* Correa) cv. Narendra Bael-9. *Int. J. Curr. Microbiol. App. Sci*, 6(6), 287-296. https://doi.org/10.20546 /ijcmas.2017.606.035.

Wu, W. and Ma, B. (2015). Integrated nutrient management (INM) for sustaining crop productivity and reducing environmental impact: A review. *Science of the Total Environment*, 512, 415-427. https://doi.org/10.1016/j.scitotenv.2014.12.101

Yadav, A. K., Singh, J. K. and Singh, H. K. (2011). Studies on integrated nutrient management in flowering, fruiting, yield and quality of mango cv. Amrapali under high-density orcharding. *Indian Journal of Horticulture*, 68 (4): 453-460. https://journal.iahs.org.in/index.php/ijh /article /view/ 1935.

Zonayet, M., Paul, A. K. and Ahmed, M. (2020). Effects of Integrated Nutrient Management on the Performance of Mango on Hills in Three Districts, Bangladesh. *Asian Journal of Soil Science and Plant Nutrition*, 1-7. https://doi.org/10.9734/ajsspn/2020/v6i330088.