

Review Article

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Effect of Integrated Nutrient Management on Vegetative Growth, Fruit Yield and Quality of Fruit Crops

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ABSTRACT

Continuous use of chemical fertilizers without organic sources poses soil health issues whereas organic manures using alone without inorganics could not be able to fulfill the requirement of high nutrient demanding crops due to the bulk and slow-acting nature of these organic fertilizer sources. However, neither organic fertilizers nor inorganic fertilizers alone can maintain productivity. The major yield limiting factors in crops production in Indian soils are NPS deficiencies. So, the option is to concentrate on alternate system like integrated nutrient management to maintain the productivity of soils where INM is promising strategy that aims to achieving harmony in the conjoint use of all resources like organic manures, bio-fertilizers, vermicompost, chemical fertilizers and other non conventional sources of plant nutrients. Before the establishment of Green Revolution majorly millets were grown and only organic manures were used, but after the Green revolution use of synthetic fertilizers increased day-by-day. Now by seeing the advantages of organic manures in crop plants are drawing the interest of soil scientists and farmers all over the world. Organic manures are the valuable resources in most of the agricultural soils as they provide not only the nutrition but also replenish the organic matter content in soils. Many studies showed that INM activities for sustainable agriculture around the world may be creative and environmentally friendly. In this review paper we will study the impact on characters of growth, quality and yield of fruit plants of integrated nutrient management.

Keywords

INM, Organic manures, Bio-fertilizers, Fruit Production, Sustainable agriculture

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Introduction

To accomplish the nutrient requirement for crops, chemical fertilizer is mostly used. Due to the hazardous effect on fruit quality, on soil, water and environmental conditions there is a need to adopt an integrated approach to supply all the essential nutrients to the plants without harming the soil and environment. By

using the both of inorganic and organic fertilizers to enhance the production of crops is known as Integrated Nutrient Management. In basic words, the INM method means the use of artificial fertilisers in addition with crop residues, organic manures, bio-fertilizers and other sources related to biological in equal amount of proportion (Mahajan *et al.*, 2009). Now a day's Integrated Nutrient

Management gaining significance in the field of fruit production as it maintains the soil health, minimize the use of chemical/artificial fertilizers or environmental pollution and provide most of the nutrients to the plants at low cost (Jamwal *et al.*, 2018) and it also prevents the loss of nutrients from plants as well as the suppression of certain insect-pests and diseases (Gaur, 2001).

INM method is also useful to those farmers who can't bear the expensive chemical fertilization to provide nutrients for any crop. Furthermore, it aims to improve the condition of land by improving their biological, mechanical, hydrological and physical properties in order to increase agricultural productivity and reduce the depletion of soil (Saikia *et al.*, 2015). Now there is a stronger awareness that integrated nutrient management will not only increase production but at the same time maintain soil quality. Its activities use FYM, soil improvement, farm waste, crop residues, composts, green manures, chemical and natural fertilizers, intercropping, cover crops, tillage maintenance and drainage systems for water management (Wu and Ma, 2015). This approach also involves innovative strategies like deep fertilizers placement and the use of urea coatings, which have been designed to increase plant uptake and reduce nutrient losses (Saikia *et al.*, 2015). These activities allow producers to concentrate on sustainable planning and to take environmental implications into greater consideration rather than only relying on returns. Integrated nutrient management can be achieved by adopting some practices such as use of organic manures like FYM, vermicompost, bio-fertilizers along with the combination of inorganic fertilizers.

Farmyard manure (FYM) supplies many nutrients especially micronutrients and they are also a good source of organic matter.

Manure increases organic matter of soil, improve soil structure or drainage in fine-textured clay soil, increases the WHC (water holding capacity of soil), serves as a source of slow release nutrients, reduces water or wind erosion, encourages the growth of earthworm and all other beneficial soil microorganisms (Rai, 2014).

Vermicompost is another component of INM which contains high organic carbon levels. It plays a major role in fertility of the soil and contains all the necessary nutrients in sufficient amount which make it as a complete and healthy plant food. It also improves soil fertility and quality by improving its chemical, biological and physical properties, growth-promoting substances and micro-organisms which is beneficial for soils or it has also the property of inhibiting pathogenic microbes. Application of vermicompost increases crop yield, nutrient status and nutrient uptake. The beneficial role of vermicompost has been also reported in fruit crops viz., strawberry (Singh *et al.*, 2008a), papaya (Acevedo and Pire, 2004), banana (Athani and Hulamani, 2000), guava (Athani *et al.*, 2007), bean plants (Mahmoud and Gad, 2020), pineapple (Mahmud *et al.*, 2019).

Bio-fertilizers are also another component of INM containing living organisms which increases the supplements of primary nutrients to the main crop. These are differ from chemical or organic fertilizers in such a way, that it cannot supply direct nutrition to plants and they are the culture of special or specific fungi and bacteria, comparatively simple and have a less cost of installation. Bio-fertilizer increases overall development of vegetative growth parameters like in higher growth rates, stem girth, also in yield development, fruit quality, fruit weight, TSS of fruit, and it also reduces acidity as compared to chemical fertilizer (Alam and

Seth., 2014). Bio-fertilizers have the ability to solubilises 30–50 kg P₂O₅ /ha/year, fixes 20–200 kg N/ha/year (Hazarika and Ansari, 2007). The beneficial role of bio-fertilizers has been reported in fruit crops viz. strawberry (Kumar *et al.*, 2019) and mango (Poonia *et al.*, 2018).

Thus, INM system can increase productivity of crops as well as improves condition of soil through synergistic effects. Major components of INM are as follows:

Incorporating soil fertility maintaining crops such as legumes, green manures etc.

Recycling the crop residues.

Using organic manures viz., vermicompost, FYM, biogas, compost, poultry manure, Phospho-compost, slurry, Press mud cakes.

Efficient genotypes.

Balanced use of nutrients from fertilizers according to the particular crop requirements and aims to increase yields.

Application of biological substances (Jat *et al.*, 2015).

Effect of inm on yield, growth and quality of fruit crops

Mango

Zonayet *et al.*, (2020) reported that In Khagrachari site, the highest mango yield 22.30 kg/plant was in T₄ treatment (150% of T₂). In Bandarban site, the highest mango yield 48.25 kg/plant found in T₃ treatment (125% of T₂). In Rangamati site, the highest mango yield 23.10 kg/plant found in T₄ treatment (150% of T₂).

In most cases the significant difference in yields were found in T₄ treatments in three districts. In current studies the fruit yield increased might be because of the optimum

nutrient supply with combined use of chemical bio-organic and fertilizers in rhizosphere.

Nehete and Jadav (2019) reported that the highest TSS (21.43%), total sugar (18.82%), maximum ascorbic acid (42.76 mg), reducing sugars (8.80%) of Mango cv. Amrapali was observed in application of (T₁₃) N 70%+ P₂O₅ 85% + PSB + Azotobacter from the other treatments. While it was noticed that the higher yield (54.00 kg/tree) comes under application of (T₁₀) N 85% + P₂O₅ 85% + PSB + Azotobacter which was closely related with 85% N + 100% P₂O₅ + PSB + Azotobacter (T₈) and 70% N + 85% P₂O₅ + PSB + Azotobacter (T₁₃).

Gautam *et al.*, (2012) observed that in cv. Sunderja the treatment T₈ containing N 500g + P 250g + K 250g /tree + vermicompost 10 kg + 50 kg FYM enhances the yield contributing parameters such as the number of fruits/panicle, fruit yield; the fruiting parameters such as the fruit width, length, weight and pulp weight or vegetative growth parameters like the maximum canopy or plant spreading (E-W) and (N-S), plant height as against to other treatments.

Yadav *et al.*, (2011) found that the physical parameters of cv. Amrapali i.e. highest fruit width (6.62 and 6.48 cm), fruit length (9.88 and 10.08 cm), weight (151.25 and 153.00 g), stone weight (26.45 and 26.62 g), pulp weight (97.06 and 97.08 g), maximum TSS (23.72 and 23.91°Brix), pulp: stone ratio (3.693 and 3.694), 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) were observed under the treatment of T₈ containing (RDF of NPK + PSB + Azotobacter + vermi-compost + paclobutrazol+ Fe + Zn) was closely followed by T₁₂ (RDF of NPK + PSB + Azotobacter +

BD compost + paclobutrazol + Fe + Zn) over the two experimental years.

Singh *et al.*, (2015) concluded that in Mango Fruit cv. Himsagar the T₆ treatment containing 500g N : 250g P : 250g K per tree per year + 250g Azospirillum + 50kg FYM recorded the highest tree height (108.00 cm), fruit weight (263.10g), plant spread in N-S (105cm) and E-W(123cm) direction, tree volume (85.95 m³), total number of fruits (234.12) and yield per tree (58.56 kg) than all other treatments.

Hasan *et al.*, (2013) reported that in Mango Fruit cv. Himsagar by analyzing all the results, the application of vermicompost in combination with (T₇) 850 g: 425g: 1000g NPK + 250 gm PSB + Azospirillum 250 gm + 100 gm borax + ZnSO₄ 100 gm / tree / year shows a substantial improvement in fruit length (9.53 cm), weight (273.20 g), highest TSS (21.57°Brix), pulp weight (180.20), total sugar (11.32%), ascorbic acid (25.68 mg per 100 gram) and pulp content (65.96%) and lowest acid content than all other treatments.

Talang *et al.*, (2017) revealed that in Mango Fruit cv. Himsagar with treatment containing half (1000:500:1000 g NPK/tree) + 50 kg FYM + Azospirillum (250 g) + 100 g potassium mobiliser (T₆) recorded maximum girth of stem (64.91 cm), plant height (5.79 m), tree spread in N-S (5.46m) and E-W (5.63m) direction while maximum fruit number (230.31/tree), yield (60.22 kg), weight (261.48 g), fruit TSS (19.66 °Brix), total sugars (16.48%), ascorbic acid (33.56 mg per 100 gram pulp), $\hat{\alpha}$ -carotene (6935 μ g per 100 gram pulp) recorded under T₈ consisting of half (1000:500:1000 g NPK/tree)+50 kg FYM+5 kg vermicompost +100 g potassium mobiliser as compared to other treatments.

Sharma and Sharma (2016) showed that in Mango Fruit cv. Amrapali application of 520g N: 160g P: 450g K per plant along with 25 kg vermicompost + 2.5 kg Oil cake + PSB + VAM + Azotobacter + TV (100g each) recorded maximum crown height (78.3cm), crown length (197.4cm), crown width E-W (248.4cm), crown width N-S (251.7cm), shoot length (16.1cm), number of panicle (40.0) and length of panicle (39.7cm) than control and other treatments.

Peach

Solanki *et al.*, (2020) observed that the yield (20.16 kg per tree) and fruit set (87.70%) of Peach cv. July Elberta was identified considerably higher by the application of RDF 75% + 15 kg vermicompost/tree.

It was also found that cumulative breadth of fruit (61.89 mm), highest length of fruit (64.06 mm), total sugars (7.51%), TSS (13.33 °B) and weight (129.51 g) under RDF 75% + 15 kg vermicompost per tree.

Pomegranate

Gajbhiye *et al.*, (2020) concluded that the higher fruit set (84.39%), number of flowers (204.75), fruit wt. (244.82 g) and yield (41.21 kg/tree) of Pomegranate were recorded with treatment T₇ (INM: Compost + Solubilizers + RDF + Umber (*Ficus racemosa*) Rhizosphere hybridised soil) followed with the treatment T₆ (INM : compost + solubilizers + RDF + Antibiotics) with values number of flowers (189.50), maximum fruit set (82.08 per cent), the yield (37.53 kg tree⁻¹) and the maximum weight (240.49 g) over other treatments under study whereas, the lower (61.25) number of flowers, minimum fruit set (68.15%), weight (188.38 g) and yield (9.08 kg tree⁻¹) were observed under the absolute T₁ control.

Banana

Patil and Shinde (2013) revealed that in banana cv. Ardhapuri the highest leaf number (32.30), maximum leaf area i.e. 17.93 m², girth (81.34 cm) and height (190.84 cm) were observed by the application of T₃ containing 50% RDF + Farmyard manure + PSB 50 g + 50 g Azotobacter + VAM 250 gram per plant. Likewise, the yield contributing factors like yield (85.80 t/ha) and bunch wt (19.31 kg) were found higher in T₃. The treatment of RDF 50% + Farmyard manure + PSB 50 g + Azotobacter 50 g + 250g VAM per plant were found to be advantageous for the yield and growth of banana.

Kuttimani *et al.*, (2013) with their studies concluded that 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) were observed throughout 2010-11 and 2011-12 respectively by the application of RDF 100% + Wellgro soil 40%. Similarly, there has been a substantial increase over RDF 100% with either 40% Wellgro soil or 10 kg FYM plant⁻¹ over both the experimental years with growth parameters such as the index of the leaf area and the crop growth, net assimilation rate, relative rate of growth, the absolute rate of growth and physiological parameters like nitrate reductase activity, soluble protein and total chlorophyll content. Hence, integrated nutrient management approaches have proved to be the most appropriate choice for optimising banana growth and physiological parameters.

Bhalerao *et al.*, (2009) observed in banana cv. Grand Naine the treatment containing 100% RDF + FYM 10 kg + PSB 25 g + Azospirillum 25 g were beneficial for the yield of banana which was closely related to treatment containing 50% NPK from inorganic and bio-fertilizers and 50% NPK through organic i.e. Green manure + FYM. Furthermore, it had

been recognized that organic manure alone was not effective for optimum production relative to integrated nutrient management.

Nayyer *et al.*, (2014) revealed that in Banana cv. Grand Naine the pseudo girth (67.98cm), stem height (150.27 cm), inflorescence length (118.50 cm), leaf numbers (34.66) were higher in plants treated with RDF 100% + Azospirillum 50 g + *T. harzianum* 50g + 50 g PSB /plant with early flowering (253.33 days) or flowering to bunch harvesting (110.00 days) as opposed to other treatments. Similar treatment was also beneficial for increasing the fingers numbers/hand (19.33) or per bunch (160.00), bunch wt. (24.50 kg), finger wt. (140.00 g), diameter (15.20cm), length (20.33cm), pulp percentage (82.17%), total sugars (18.66%), TSS (19.26⁰B) and pulp: peel ratio (4.60) with minimum titratable acidity (0.40%).

Syed (2009) stated that in banana cv. Ardhapuri the best application for the development of the bunch wt. (18.4 kg) and yield (81.8 ton/ha) was N 200g + P₂O₅ 150g + K₂O 200g + organic slurry 6 litres/plant among different combinations. This treatment also increased NPK availability in soil or boosted the nutritional level in leaf tissues index.

Papaya

Kanwar *et al.*, (2020) studied that among the all treatment highest fruit number (78.33), yield (71.32 kg/ plant), fruit weight (1486 g) and length (22.66 cm) of Papaya fruit cv. Red lady was observed under treatment T₈ (75% RDF + 100 g Azotobacter +100 g PSB+ Vermicompost 10 kg per plant) or it was closely followed by T₉ and T₇ treatment i.e. number of fruits (74.33 and 71.00), fruit yield (67.86 and 66.93 kg), fruits length (19.33 and 21.33) and fruit weight were (1423.33 g and 1340.00 g) respectively whereas less number

of fruits or yield have been registered in T₀ (RDF + Control).

Singh and Varu (2013) concluded that in papaya cv. Madhubindu the treatment comprising of half RDF (N 100 g + P 100 g + K 125 g /plant) + PSB 2.5g /m²+ Azotobacter 50 g/plant (T₈) have been found to have increased the yield and growth parameter with the greatest survival rate (98.67 percent), length of fruit (30 cm), weight (1670 g), girth (22 cm), number of fruits (45.33), yield per plant, hectare or plot (78 kg/313 kg/259.97 t, respectively). Similarly, quality factors like TSS, total, reducing and non-reducing sugars (15.47°Brix, 13.58, 11.10 and 2.43%, respectively) had been noted maximum in the same application. It was however found to be equivalent to 1/4 RDF+ 3/4 Jivamrut (T₁₃). Low output for all parameters has also been observed in control.

Singh *et al.*, (2008b) observed that in 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 per100 gram pulp), shelf life (12 days) were concluded with 75% RDF + bacteria culture of rhizosphere + 25% vermicompost treatment whereas the mean height of the plant (185.35 cm) and the length of the petiole (8.42 cm) comes under 100% RDF alone. The 75% RDF + bacteria culture of rhizosphere+ 25% vermicompost was considered more superior and commercially feasible than any other treatments.

Tandel *et al.*, (2014) revealed that in Papaya cv. Red Lady the treatment T₆ containing of 50 % RDN from inorganic fertilizer + 25 % RDN from (bio compost + castor cake, respectively) suggested higher growth values like height of plant (185.39 cm), stem of girth (50.51 cm) and leaf number (44.92). And this treatment also influenced the physiological

parameters viz., photosynthetic rate, transpiration rate, total chlorophyll content and leaf temperature.

Kinnow

Bakshi *et al.*, (2018) shown that in Kinnow Mandarin the highest height of plant (14.30%), canopy volume (38.95%) and plant spreading direction (E-W 14.0% and N-S 14.05%) was reported by the treatment of 100% N as urea + Azotobacter in combination with recommended MOP and SSP. However, the yield contributing factors like width of fruit (6.53 cm), length (5.84 cm), number of fruits (165.5), volume of fruit (191.83 cc), weight (188.18 g) and yield of kinnow fruit (31.14 kg) per plant with the applications of N 50% by poultry manure or 50% remaining N by urea in conjunction with the Azotobacter were obtained higher. It was concluded that application of 50% nitrogen as urea can be substituted by poultry manure application along with Azotobacter treatment.

Acid lime

Kumar *et al.*, (2020) concluded that the highest length of fruit (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%) of Acid Lime were recorded under T₁₂ - 50% RDF + 75% FYM + 75% Vermicompost + Biofertilizers (25g Azotobacter + 25g PSB + 150g VAM) and the minimum results comes under control.

Lal and Dayal (2014) announced in Acid Lime fruit the treatment containing T₆ (50 per cent RDF + 50 per cent by goat manure) was superior from the remaining treatments showing the maximum yield (7.58 kg/tree) and growth of fruit with the highest length of

fruit (4.43 cm), weight (35.71 g) and diameter (3.99 cm) registered under T₆. Similarly, the maximum TSS (10.42%), juice (43.37%) and ascorbic acid content (86.33mg per 100 gram juice) with less number of seeds (1.15 per cent) and acidity content (6.06 per cent) were also generated in the same procedure.

Lemon

Ghosh *et al.*, (2020) concluded that the considerably highest flowers number of Lemon cv. Assam Lemon per plant was recorded (399, 371.67 and 250.33) in N₄ treatment containing (75% RDF +VAM +Azotobacter + Vermicompost) and the lowest flowers number (360,386.33 and 224.33) were seen in Vermicompost treatment (N₃) at Mrig, Ambe and Hasth bahar respectively. Bio-fertilizer's role in fixing nitrogen from atmosphere and VAM in phosphorus solubilization is responsible for preserving healthier environment or soil that was eventually reflected in the tree flowering. It also reported the substantially highest fruit yield (7.67 kg, 13.83 kg and 2.14 kg / plant) in treatment with N₄.

Mahakulkar *et al.*, (2016) reported in Rough Lemon Fruits the results indicated that fruit volume (150.95 cc), fruit diameter (8.00 cm), seed germination (68.21%) and seed vigour (1273.35) was found better in the plants treated with T₈ [75% RDF (450 g N + 225 g P₂O₅ + 225 g K₂O/plant) + 500 g AM (Actinomycetes)/plant + 100 g Azotobacter /plant + 100 g PSB/plant + 15 kg vermicompost/plant], whereas TSS and acidity of fruits showed non-significant results with respect to different combinations.

Kumar *et al.*, (2018) indicated that in Lemon fruit application of 75% NPK (315g N + 210g P + 315g K) +10kg NC + 200g PSB + 200g Azotobacter found to be statistically significant and most beneficial and promotive

in relation to maximum percent increase in tree height (14.44 and 15.34%), tree spread (16.20 and 17.68%), trunk diameter (11.21 and 13.55), maximum fruit set (79.19 and 80.54%) and fruit retention was recorded while maximum fruit drop (64.34 and 63.35%) recorded under control treatment during 2011–12 and 2012–13, respectively.

Guava

Dheware *et al.*, (2020) reported that Maximum flowering (92.33%) and highest TSS (10.37⁰B) of Guava Fruit cv. Allahabad Safeda observed under treatment T₄ containing 250 g PSB + Vermicompost 30 kg + 250 g Azospirillum while maximum average weight of fruits (400 g), yield of fruits (29.60 kg/tree and 11.84 t/ha) and lowest acidity content (0.19%) were seen with T₆ application of Vermicompost 30 kg + 250 g PSB + 250 g Azospirillum + Vermi wash foliar spray (dilution with water @ 1:1).

Sharma *et al.*, (2013) revealed that the Guava quality and yield parameters like maximum length of fruit (8.39 cm), width (7.94cm), pectin (0.81 per cent), weight (244.24 g) and yield (41.14 kg / plant) under treatment containing 75% N from inorganic + 25% N from FYM while 50% N from inorganic + 50% N from FYM + Azotobacter showed highest total sugars (8.61%) or TSS (12.95⁰B) and minimum physiological weight loss (14.29%) at an interval of ten days under appropriate situations.

Binepal *et al.*, (2013) concluded that substantially maximum length (7.52 cm) of Guava fruit, diameter (7.91cm), volume (217.41 ml), thickness and weight of pulp (2.46 cm) and (211.61 g) and weight of seed (8.76 g) by the treatment of T₉ (100%N + P₂O₅ 100% + PSB + Azospirillum + Vermicompost 10 kg) while lowest percentage of pulp (96.08 %) were found

under the treatment T₁₀ (75% N + 75% P₂O₅ + PSB + Azospirillum + Vermicompost 10 kg) which was higher than control.

Shukla *et al.*, (2009) concluded that the treatment of NPK 50% + 250 g Azotobacter + 50 kg FYM (T₇) greatly enhances the volume of canopy (201.42 m³), ascorbic acid (198.30 mg per 100 gram pulp), weight of fruit (153.30 g), total sugars (8.10%), reducing sugars (4.77%), TSS (14%), leaf nitrogen, phosphorus, potassium content (1.40%, 0.46%, 1.17%, respectively) of Guava cv. Sardar. This combination of 50% NPK + 250 g Azotobacter + 50 kg FYM (T₇) also gave considerably higher yield (28.95 kg) with highest B: C (2.53: 1) ratio.

Pilania *et al.*, (2010) observed that the pruning effect with INM practice i.e. by the application of 50g N + 20g P + 50g K + *Aspergillus niger* + Azotobacter + 5 kg vermicompost + 25% pruning intensity (F₅ I₁) showed highest flowers per shoot (57.83), canopy volume (0.96 m³), while 50g N + 20g P + 50g K + *Aspergillus niger* + Azotobacter + 5 kg vermicompost + 75% pruning intensity (F₅ I₃) gave maximum diameter of fruit 5.31 cm, weight of fruit (158.06 g), pulp seed ratio and weight (39.93 and 154.19 g) in both years. However, maximum area of leaf (59.46 cm²) and yield (6.68 kg/ plant and 33.43 t/ha) comes with 50g N + 20g P + 50g K + *Aspergillus niger* + Azotobacter + 5 kg vermicompost + pruning intensity 50% (F₅ I₂) with B : C (4.33) ratio.

Jamwal *et al.*, (2018) reported that the maximum tree height (21.99%), canopy spread N-S (23.57%) and E-W direction (23.50%) of Guava fruit obtained with the application of Azotobacter + (100% Nitrogen through urea) T₁₁, whereas maximum number of fruits/tree (21), Maximum average fruit weight (190.10gm), Maximum length of fruit (7.10cm), diameter (7.15 cm), volume (192.13), yield/tree (3.99Kg), Fruit yield/ha

(199.58 q) has been obtained with treatment T₁₄ Azotobacter + (75% Nitrogen through urea + Vermicompost 25 %).

Singh *et al.*, (2018) indicated that the treatment containing 75% RDF + FYM 40 Kg /tree (T₃) recorded maximum plant height (0.64m), trunk girth (5.46 cm), tree canopy spread increment (0.46m), number of leaves and branches per shoot (7.29) and (12.56), selected shoot length (26.90 cm) and diameter (4.26 cm), fruit numbers (307.32), number of flowers (617.09), fruit set (49.80%), yield (54.27 kg/plant or 8.68 t/ha) in Guava cv. L-49 as compared to other treatments and minimum parameters seen under control (T₁) during both years on pooled basis.

Sapota

Sheik *et al.*, (2019) concluded highest yield of Sapota trees (70.04 and 64.27 kg/plant), ascorbic acid (2.85 and 2.69 mg/100g), total sugar (18.35 % and 18.19 %), reducing sugar (13.10 % and 13.02 %) and non-reducing sugar content (5.25 % and 5.17 %) for first and second season respectively were observed under the application of T₈ RDF (1000 : 1000 : 1500 g NPK/tree) + vermicompost @ 12.5 kg/tree + EM (effective microorganisms). This was followed by the treatment T₇ (FYM @ 50 kg/tree + RDF + EM 1:250 dilution). The lowest values except acidity were obtained in control treatment.

Meena *et al.*, (2019) reported that application of 2/3rd part of RDF + 250 g Azotobacter + 250 g Azospirillum + 50 kg FYM plant⁻¹ (T₁₁) considerably increases the yield (29.03 kg/tree) and number of fruits (327.88) per plant whereas all yield parameters were observed minimum under control. Baviskar *et al.*, (2011) reported that in Sapota fruits number obtained/plant (1569.33) and yield (197.53 kg/plant) were seen highest in those plants which are given by the application of T₉ (1125g N : 750g P : 375g K + 250 gm PSB

+ 250 gm Azotobacter + vermicompost 15 kg).

The fruit quality contributing factors viz., fruit volume (117.20 cc), weight (125.87g), pulp and peel weight (101.66 g) and (22.50 g), total sugars (4.24%) and TSS (23.16°B) with minimum amount of acidity (0.220%) comes under the same treatment. However, minimum fruit volume (45.00 cc), weight (61.33g), length (3.30cm), pulp and peel weight (61.33 g) and (10.63 g), breadth (3.33 cm) and yield (73.99 kg/plant) were recorded under the treatment T₁₁ (control).

Tasleema *et al.*, (2019) observed that the trees which received the application of RDF + vermicompost @ 12.5 kg tree/ + EM had recorded the tallest plant height (7.29 m), plant spread (7.19m in E-W and 7.20m in N – S) and the maximum canopy volume of 96.49 m³.

Plum

Kamatyanatti *et al.*, (2019) observed in Plum cv. Kala Amritsari the maximum height of plant (0.27 m), rise in height percentage (4.91 %), area of leaf (13.13 cm²), chlorophyll (23.88) index and annual growth of shoot (70.63 cm) were seen in the T₁₁ treatment containing (N 75% + 12.5 % N by FYM + 12.5 % N by vermicompost + bio-fertilizers) followed by T₉ (75% of N + bio-fertilizers + 25% N through FYM) and lowest height were seen in T₁ (Control) i.e. 0.14 m. While maximum fruit yield (52.14 kg/tree) was reported under T₁₁ and minimum in T₂ (50% of N + 50% N through FYM) which was (38.63 kg/tree).

Litchi

Raghavan *et al.*, (2018) concluded that highest fruit number (1281), total sugars (26.14%), yield (30.01 kg) and reducing sugar

(14.51%) per tree of Litchi cv. Muzaffarpur was seen in 500 : 250: 250 g NPK+100 g VAM +100 g PSM +150 g Azotobacter +100 kg FYM (T₉), while maximum fruit cracking recorded in control (1000 : 500 :500 g NPK). The most successful treatment of fruit yield and quality in litchi was the application of 500g N + 250g P + 250 g K +100 g VAM +100 g PSM +150 g Azotobacter +100 kg FYM (T₉) in the foothills of Arunachal Pradesh.

Phalsa

Sutariya *et al.*, (2018) revealed that the Quality attributing characters of Phalsa cv. Local viz. juice (53.07%), TSS (23.17°Brix), total sugar (6.55%), reducing sugar (2.77%), ascorbic acid (38.20 mg/ 100 g of fresh pulp) content were significantly higher with T₇ (50% N through urea + 25% N through vermicompost per plant + 100 g P₂O₅ through SSP + 50 g K₂O through MOP per plant + AAU PGPR consortium) and minimum acidity (2.02%) were shown in T₇ treatment.

Bael

Vishwakarma *et al.*, (2017) reported that in Bael cv. Narendra Bael-9 the maximum fruit length (24.00cm and 24.62cm), fruit width (18.08cm and 19.32cm), fruit weight (2.41kg/fruit and 2.45kg/fruit), number of seed per fruit (114.50 and 120.75), minimum shell weight (303.44g and 306.50g), maximum TSS (35.66°Brix and 37.85°Brix), ascorbic acid (20.75mg/ 100g pulp and 21.26mg/ 100g pulp) and Total carotene (55.84µg/100g pulp and 55.72µg/100g pulp) was recorded with the use of T₇-50 Kg FYM + 100% NPK + 200g each (Azotobacter + PSB) followed with the application of T₈ 75% NPK + 200g PSB + 200g Azotobacter +50 Kg FYM in comparison to other treatments over the two experimental years.

Walnut

Bhattarai and Tomar (2009) stated that the RDF of NPK + 50 kg vermicompost and $\frac{3}{4}$ NPK + vermicompost 68.75 kg were successful in enhancing the leaf nutritional status of Walnut.

Pineapple

Baraily and Deb (2018) observed the treatment T₉ (75% RDF of NPK + bio-fertilizer + 7.5 t/ha Vermicompost) recorded significantly maximum in fruit length without crown (21.92cm), crown length (14.91cm), crown weight (170.7g), estimated yield without crown (63.41t/ha), fruit juice content (0854.8g), TSS (13.56°Brix), reducing sugar (5.77%) which closely related by T₈ (100% of RDF of NPK + bio-fertilizer + 5 t/ha Vermicompost).

Strawberry

Umar *et al.*, (2008) observed that highest yield (i.e.372.89q per ha) comes by the treatment of fully N from urea + Azotobacter while second yield (i.e.358.43 q per ha) were seen by the treatment of 75% N as urea + 25% N as FYM + Azotobacter were closely related to each other.

Nazir *et al.*, (2015) recorded the observations on growth characters like maximum height of plant (23.39 cm), runners/plant (13.03) and plant spread (24.21cm) were in treatment PSB+ wood ash + Azotobacter + poultry manure + mustard oil cake and this treatment also improves yield (238.95g) and physical fruit characters like diameter, length, weight and volume (3.11 cm, 3.95 cm, 11.11 g, 20.39 cm³, respectively) and chemical characters like TSS(9.01°B), total sugars (7.95%) and acidity (0.857%) content.

Bhagat and Panigrahi (2020) observed the flowering and physical parameters of fruit i.e. number of flowers (43.41), number of fruits (41.80/plant), diameter (4.85cm), length (6.64cm), volume (37.17 cc), weight of fruit (43.33 g) and fruit yield (355.84 q/ha) were significantly influenced under the treatment T₁₁: (RDF + Azospirillum (@7 kg / ha) + Phosphate Solubilizing Bacteria (@6 kg / ha) + VAM (@10 kg / ha) whereas, the minimum value for the same was observed under control (T₀). Similarly, highest benefit cost ratio registered in the same treatment (4.20:1), while the lowest value (2.20:1) was observed in RDF + control.

Conclusion is as follows:

In order to optimize yield capacity, constant and inconsistent usage of chemical fertilizers in a disequilibrium ratio contributes to a decrease in soil productivity as well as plant yield production resulting in either stagnation or decrease in yield. Chemical fertilization has certainly improved crop production but to a larger extent it may lead to soil erosion and creates soil health issues, whereas the use of organic manures alone without inorganic fertilizers could not be able to fulfill the requirement of high nutrient demanding crops due to the bulk and slow-acting nature of these organic fertilizer sources. Use of bio-fertilizers which are cheaper and pollution free for increasing crop productivity have great potential in current day agriculture. But, it is very difficult to manage all the nutrient needs through organic manures and bio-fertilizers. Hence, from the above study the result is concluded that it is advisable to supply 50% of the nutrients requirement through inorganic fertilizers and rest from the organic sources. Thus, the Integrated Nutrient Management approach may help in boosting the crop production by synergistic effects and also helps in maintaining the soil conditions.

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