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RK Jat
Assistant Professor, Department of Fruit Science, College of Horticulture, SDAU, Jagudan, Mehsana, Gujarat, India

Mukesh Kumar
Assistant Professor, Department of Natural Resource Management, College of Horticulture, SDAU, Jagudan, Mehsana, Gujarat, India

Mohan Lal Jat
Research Scholar, Department of Horticulture, College of Agriculture, CCS HAU, Hisar, Haryana, India

AD Rathwa
Assistant Professor, Department of Fruit Science, College of Horticulture, SDAU, Jagudan, Mehsana, Gujarat, India

Corresponding Author:
RK Jat
Assistant Professor, Department of Fruit Science, College of Horticulture, SDAU, Jagudan, Mehsana, Gujarat, India

Integrated nutrient management in fruit production

RK Jat, Mukesh Kumar, Mohan Lal Jat and AD Rathwa

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Abstract
The indiscriminate use of chemical pesticides along with improper nutrient management is deleterious to the plant health, environment and human being who consume them. The quality attributes of different fruits are badly affected due to indiscriminate application of inorganic agro-chemicals which results in quality deterioration with less consumer preference and low returns to the growers. It also causes soil health deterioration and disturbs the soil microorganisms. Such practices are also common among the fruit growers. Due to these practices, the plants also become susceptible to several biotic and abiotic stresses. Therefore, it is a holistic approach based on usage of all possible sources of plant nutrients in an integrated manner is considered as alternative source to maintain soil fertility and plant nutrient supply for sustaining the desired crop productivity.

Keywords: Nutrient management, environment, quality, soil fertility and crop productivity

Introduction
India has been bestowed with wide range of climate and physio-geographical conditions. Due to these circumstances, various kinds of horticultural crops are well adapted for different agro climatic regions of India. Fruit crops are cultivated in India over 6506 thousand hectare with a total production of 97358 thousand metric tonnes and productivity of 14.96 t/ha (Anonymous, 2018). However, production of fruits has increased manifold over the last decade but there exists a gap between the demand and supply of fruits. Now days to feed the increasing population and provide them nutritional security are also a challenging profession to the agrarian communities. In addition to beyond facts, the fruits play an important role in human diet. They are good source of vitamins and minerals. Without them human body cannot maintain proper health and develop resistance. They also contain oils, fats and proteins which are used in metabolic activities.
Now days, inorganic fertilizers are one of the most expensive inputs in orchard management. Besides, continuous application of huge amount of chemical fertilizers hampers the soil health, soil productivity, environment, quality of produce and human being who consume them. In view of above facts, there is need to increase the production and productivity through Integrated Nutrient Management (INM).

What is Integrated Nutrient Management?
It involves the combined use of inorganic, organic and biological sources of essential plant nutrients to sustain optimum crop yield and also improve or maintain the physico-chemical properties of soil. It provides crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe. The principal aim of the integrated approach is to utilize all the possible sources of plant nutrition in a judicious & efficient manner.

Objectives of INM
- To reduce the dependence on chemical fertilizers
- To reduce inputs cost by conserving locally available resources & utilize them in a efficient manner
- To maintain productivity on sustainable basis without affecting soil health
- To increase the fertilizer use efficiency

- To utilize the potential benefits of green manures, leguminous crops and biofertilizers
- To prevent degradation of the environment
- To meet the social and economic aspirations of the farmers without harming the natural resource base of the agricultural production

Requirement of INM

It is required due to the following reasons

- The decline in productivity can be attributed to the appearance of deficiency in secondary and micronutrients
- Consistent increasing cost of chemical fertilizers
- Unavailability of fertilizers as per requirement
- Environmental pollution and its ill effects on soil, animals and human being due to continuous and excessive use of chemical fertilizers
- Continuous depletion of soil nutrients
- Without an integrated supply and use of plant nutrients from chemical fertilizer and organic sources, better production is not possible
- The fertilizer production in our country is less than the required amount

Therefore, organic manures and biofertilizers have to be looked for as alternate sources to meet the nutrient requirement of crops and to bridge the more gaps. Such integrated approach will help to maintain soil health and productivity and improving farmer's profitability. It involves following components.

1. Use of organic manures
2. Use of biofertilizers
3. Use of chemical fertilizers
4. Management of problematic soils
5. Irrigation water management

Organic manures

Organic manures defined as materials which are organic in nature and derived from plant and animal origin used to improve fertility and productivity of soil. The manures contain organic matter in large proportion and plant nutrients in small quantities. They are mostly used to improve the soil productivity by correcting soil physical, chemical and biological properties. E.g. FYM, vermicompost, compost, oil cakes, green manure *etc*.

Green decomposed material used as manure is called green manure. It is obtained in two ways by growing green manure crops or collecting green leaf (along with twigs) from plants grown in wasteland, fields, bunds and forest. Green manuring is practised in the field plants which usually belong to leguminous family and incorporate into the soil after sufficient growth. The plants that are grown for green manure known as green manure crops.

Crop residues are materials left in an agricultural field or orchard after the crop has been harvested and after mostly leaf fall stage in case of fruit crops. These residues include stalks and stubble (stems), leaves, seed pods *etc*. These are also very valuable animal feed. Sometimes poultry manure/droppings are mixed with other additives and used as fish or cattle feed. Management of crop residues is either through removal, burning or incorporation into soil. Burning is a minor practice in India. Crop residues are an important source of organic matter that can be returned to soil for nutrient recycling, and to improve soil physical, chemical and biological properties (Kumar and Goh, 2000).

Biofertilizers

The products containing living cells of different types of microorganisms which have an ability to mobilise nutritionally important elements from non-usable to usable form through biological process. E.g. N-fixing bacteria (*Rhizobium*, *Azotobactor*, *Azospirillium etc*.) phosphorus solublising bacteria (PSB), potassium solublising microorganisms (KSM), *Vesicular Arbuscular Mycorrhizae* (VAM) *etc*.

Chemical fertilizers

Fertilizers are the materials which are used to fertilize (to provide one or more essential nutrients) the crops are generally termed as fertilizers but now days; the term fertilizer is widely used for commercially manufactured inorganic fertilizers. Thus, chemical fertilizers defined as the any material (solid, liquid or gas) containing one or more nutrient elements in the form of chemical compounds of the organic or inorganic nature.

Management of problematic soils

Problematic soils such as saline soils, alkali soils, acid soils, waterlogged soils are known to decrease the productivity of the soil. These soils should be regularly managed and reclaimed through the application of soil amendments such as gypsum for alkali soils, lime for acid soils, use of good quality water for saline soils and use of other organic and inorganic materials based on soil test results. It helps to improve soil fertility and productivity and sustain the crop yield.

Irrigation water management

Plants absorb the nutrients from the soil only in a dissolved state and sufficient moisture is therefore required for utilizing the nutrients of the soil. Management of moisture in the soil by improved and modern irrigation techniques like drip or sprinkler or basin where the rainfall is low and draining the soil where it is subjected to stagnation of water helps to increase water and nutrient availability to the crops.

Major Steps in Integrated Nutrient Management

- Evaluate the field for potential of crop yield
- Determine residual nutrient availability and major yield limiting factors for each field
- Based on soil and leaf nutrient analysis, correction of nutrient deficiency will result in higher yield
- Evaluate availability of on-farm nutrients from plant residues, green manures, cover crops, animal manures, symbiotic N-fixation by legumes and nutrients in irrigation water
- Estimate and prioritize supplemental nutrient requirements for each field and crop
- Establish the most efficient nutrient application programme with respect to crop, nutrient source, time of application, placement method and quantity
- Regularly evaluate the results of nutrient application in terms of yield and quality responses of crop, residual nutrient levels and changes in soil quality

In context to this, integrated nutrient management is a holistic approach that has intensive uses of organic manure along with biofertilizers, in combination of inorganic fertilizers, have resulted in beneficial effects on growth, yield and quality of some fruit crops which were reviewed under.

Mango

Kundu *et al.* (2011) [22] conducted an experiment on mango at Horticultural Research Station, Bidhan Chandra Krishi Viswavidyalaya, West Bengal and obtained higher fruit yield when the plants were treated with 100% NPK + *Azotobacter* + VAM (98.l kg/plant) or 75% NPK + *Azotobacter* + VAM (93.5 kg/plant) as compared to much lesser yield (60 Kg/plant) with 100% NPK. It was concluded that the treatments 100% NPK + *Azotobacter* + VAM and 75% NPK + *Azotobacter* + VAM were effective and may be adopted to improve the vegetative growth and productivity with quality fruits. Singh and Banik (2011) [38] reported significantly maximum physical parameters *viz*., fruit weight (244.22 g), pulp weight (189.86 g), with minimum stone weight (26.18 g) through application of ½ RD of NPK + 50 kg FYM + 250 g *Azospiriliium* treatment. They also observed significantly maximum quality parameters *viz*., TSS (19.24 ^{0}Brix), reducing sugar (4.44%), total sugar (15.48%) with minimum acidity (0.14%) in same treatment. Yadav *et al.* (2011) [46, 47] recorded significantly maximum fruit length (10.08 cm), fruit width (6.62 cm), fruit weight (153 g), pulp weight (97.08 g), number of fruits/tree (184.67), fruit yield (26.72 q/ha), TSS (23.91 ^{0}Brix), ascorbic acid (45.63 mg/100 g) and total sugar (18.34%) with minimum acidity (0.121%) when mango trees treated with the application of recommended dose of NPK (500:250:250 g/tree) + 30 kg vermicompost + 250 g *Azotobacter* + 250 g PSB + Zn (0.40%) + paclobutrazol 5 ml/tree. Gautam *et al.* (2012) [12] observed that number of fruits/tree (409.6) and fruit yield (124.67 kg/tree) were found significantly maximum when mango plants treated with application of ½ RD of NPK + 50 kg FYM + 10 kg vermicompost/plant. Kumar and Kumar (2013) [20] revealed that number of fruits/tree (840.0) and fruit yield (127.43 kg/tree) were found significantly maximum with application of 75 kg vermicompost/tree. Singh *et al*. (2017) studied the effect of integrated nutrient management on mango cv. Amrapali under high density planting at Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut and reported that maximum plant height, spread and number of panicles/plant were recorded in the plants treated with 75% RDF (750:375:750 g of $N:P_2O_5:K_2O$) + 40 kg vermicompost + 250 g *Azotobacter* + 250 g PSB/plant closely followed by 75% RDF + 20 kg vermicompost + 250 g *Azotobacter* + 250 g PSB/plant. Whereas, they obtained the highest fruit length, fruit width, fruit weight, fruit yield, TSS, reducing sugar, non-reducing, total sugar and lowest acidity in 75% RDF (750:375:750 g of $N:P_2O_5:K_2O$) + 20 kg vermicompost + 250 g *Azotobacter* + 250 g PSB per plant treatment closely followed by 75% RDF + 40 kg vermicompost + 250 g *Azotobacter* + 250 g PSB per plant.

Banana

Hazarika and Ansari (2010) observed that bunch weight (16.50 kg), number of hands per branch (9.32) and fingers per hand (23.04) and yield (73.96 ton/ha) were significantly recorded maximum when banana plants treated with 100% RD of NPK (P as rock phosphate) + 12 kg FYM + 50 g *Azospirillium* + 50 g PSB /plant. Butani *et al.* (2012) found that application of full dose of NPK (300:90:200 g/tree) + 8 kg vermicompost gave maximum yield (55.64 ton/hectare). Patil and Shinde (2013) [30] reported that the maximum plant height (190.84 cm), plant girth (81.34 cm), number of leaves per plant (32.30) and leaf area (17.93 m^2) with the minimum number of days (211.03) for shooting after planting and number of days for harvesting after shooting (117.46) were recorded under 50 per cent RDF + FYM + *Azotobacter* (50 g/plant) + PSB (50 g/plant) + VAM *Glomus fasciculatum* (250 g/plant). Similarly, this treatment was found beneficial in increasing bunch weight (19.31 kg) and yield per hectare of banana (85.80 t/ha). Vanilarasu and Balakrishnamurthy (2014) studied that combined application of organic manures, amendments and green manures (FYM @ 10 kg + neem cake @ 1.25 kg + vermicompost @ 5 kg and wood ash @ 1.75 kg per plant + triple green manuring with sunhemp + double intercropping of cow pea + biofertilizers *viz., Vesicular Arbuscular Mycorrhizae* @ 25 g, *Azospirillum* @ 50 g, phosphate solubilizing bacteria @ 50 g and *Trichoderma harzianum* @ 50 g per plant) registered the maximum growth and resulted in increasing yield and yield attributes, leaf nutrient status of N, P and K at 5th and 7th month after planting of banana and soil physiochemical properties at harvesting stage. Sangeeta *et al.* (2017) reported maximum TSS (24.01 ºBrix), reducing sugar (18.92%), non-reducing sugar (3.51%) and total sugar (22.43%) by application of FYM @ 10 kg per tree + neem cake @ 1.25 kg per tree + vermicompost @ 5 kg per tree + wood ash @ 3.75 kg per tree in banana crop. Suhasini *et al*. (2018) studied the effect of integrated nutrient management on growth parameters of banana cv. Rajapuri and observed the highest plant height (197.44 cm) and pseudostem girth (73.05 cm) at shooting with application of RDF 100% (200,100,300 g NPK) + 20 kg FYM + PSB (20 g) + *Azospirilum* (20 g) per plant.

Acid lime

Musmade *et al*. (2009) recorded significantly higher yield (147.65 kg/plant) with better quality fruits were obtained from the 10 year old trees receiving 600:300:600 g NPK + 15 kg each of FYM and neem cake per plant per year. Lal and Dayal (2014) recorded the maximum vegetative growth and yield (7.58 kg per tree) of acid lime having highest fruit length (4.43 cm), fruit diameter (3.99 cm) and fruit weight (35.71 g) along with minimum seed (1.15%) and acidity content (6.06%) when plants treated with 50 per cent RDF + 50 per cent through goat manure. Similarly, maximum juice (43.37%), TSS (10.42%) and ascorbic acid content (86.33 mg/100 g juice) in the same treatment. Nurbhanej *et al.* (2016) studied the effect of integrated nutrient management on yield and quality of acid lime at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand and reported that the acid lime trees treated with 75% RDF (675:562:375 g NPK) + 9 kg vermicompost + AAU PGPR Consortium (3.5 ml/tree) gave maximum fruit yield, fruit volume, fruit diameter, fruit weight, TSS, ascorbic acid and acidity. Prabhu *et al*. (2018) revealed that the application of 100 per cent recommended dose of fertilizers (600:200:300 g NPK per plant/year) + *Azospirillum* (100 g per plant) + *phosphobacteria* (100 g per plant) + *Arbuscular Mycorrizhal* Fungi (500 g per plant) + *Trichoderma harzianum* (100 g per plant) has showed a superior performance with respect to yield, yield attributing components and quality attributes of acid lime.

Guava

Dey *et al.* (2005) reported significantly maximum fruit weight (154.50 g), fruit length (4.27 cm) and fruit diameter (4.68 cm) with application of 200 g *Phosphobacterin*/tree whereas TSS (10.10 ^{0}Brix) and vitamin C (151.8 mg/100 g) were found significantly maximum with application of 200 g VAM/tree. Ram *et al.* (2007) reported that the application of different fertilizers, organic manures and biofertilizers improve the vegetative growth, number of fruits and yield of guava cv. Sardar. Dutta *et al.* (2009) [10] observed that fruit length (9.5 cm), fruit diameter (8.9 cm), weight of fruit (255.0 g), weight of pulp (205.0 g) and fruit yield (51.26 kg/plant) were found significantly maximum in 100% N + 100% P_2O_5 + 30 g *Azospirillium* + 30 g VAM/plant treatment. Godage *et al.* (2013) [13] reported significantly minimum days of flowering (32.33) and the highest fruit characters like number of flowers/branch (25.33), fruit set/branch (90.20%), fruit diameter (10.07 cm) and fruit weight (215.06 g) when guava plants treated with 75% N + 75% P_2O_5 + 100% K_2O + *Azotobacter* 5ml /tree + PSB 5ml /tree. Shukla *et al.* (2014) [36] stated that application of 10 kg vermicompost + *Azotobacter* + phosphate solubilizing microrganism + *Trichoderma harzianum* + organic mulching recorded the highest fruit weight, fruit diameter, fruit length, TSS, titratable acidity, total sugars and ascorbic acid content. Dwivedi and Agnihotri (2018) [11] revealed that application of 50 per cent RDF (250:100:250 g NPK) + 25 kg FYM + 5 kg vermicompost per tree gave maximum plant height (3.93 m) and canopy height (3.06 m), spread E-W and N-S (3.85 & 3.66 m), plant girth (0.33 m), leaf length (6.99 cm) and width (3.51 cm) and tree volume (369 m^3) as well as significantly increased yield attributes *viz*., number of fruits per tree (200), fruit weight (258 g) and yield per tree (34.3 kg). Kumrawat *et al*. (2018) [21] revealed that the application of 100% NPK + 5 kg vermicompost + 150 gm *Azatobactor* recorded maximum TSS (12.67 ºBrix), TSS/acid ratio (56.39), ascorbic acid (206.07 mg/100 g pulp), pectin (0.75%), total sugars (8.21%), reducing sugars (4.15%) and non-reducing sugars (4.06%) with minimum acidity (0.23%). Whereas, the maximum number of fruits per tree (286.91), fruit weight (209.88 g) and yield per tree (60.20 kg) were recorded with the application of 100% NPK + 5 kg vermicompost + 150 g VAM. Tiwari *et al*. (2018) [42] observed maximum plant height (4.07 m), circumference of root stock (38.51 m) and scion (36.57), plant spread E-W and N-S (3.79 & 3.80 m), leaf length (17.98 cm), leaf width (8.94 cm), tree volume (184 m^3) and fruit yield (65.58 kg/tree and 181.64 q/ha) in the trees treated with 100% NPK (500:250:500 g) + Zn (0.5%), B (0.2%), Mn (1%) as foliar spray twice + organic mulch (10 cm thick).

Sapota

Patel and Naik (2010) [28] revealed that application of 5 kg vermicompost + 400 + 60 + 300 g NPK/tree was found to be superior in extending post-harvest shelf-life and physico-chemical parameters *viz*., volume, peel weight, pulp weight, colour acceptance, TSS, reducing sugar, non reducing sugar, acidity and vitamin C content, while maximum firmness of fruits was found under 25 kg FYM + 400 + 60 + 300 g NPK/tree. Organoleptic test in respect of colour and texture was more acceptable under 5 kg vermicompost + 400 + 60 + 300 kg NPK/tree while flavour and taste was superior under 25 kg FYM alone/tree. Baviskar *et al.* (2011) [3] concluded that fruit weight (125.87 g), fruit length (4.36 cm), fruit breadth (5.26 cm), fruit volume (117.20 cc), pulp weight (101.66 g), peel weight (22.50 g), number of fruits/plant (1569.33) and fruit yield (197.53 kg/plant) were found significantly maximum in 1125:750:375 g NPK + 15 kg vermicompost + 250 g *Azotobacter* + 250 g PSB/plant treatment. Similarly, quality traits like TSS (23.16 ^{0}Brix) and total sugar (18.03%) were found significantly maximum with minimum acidity (0.050%) in same treatment. Patel *et al.* (2017) [29] recorded maximum total soluble solids (24.50 ºBrix), acidity (0.21%), ascorbic acid (20.37 mg/100 g pulp), reducing sugar (10.52%), non-reducing sugar (12.01%), total sugars (22.53%), shelf life of fruits (8.05), fruit firmness (7.78 kg/cm^2) and physiological loss in weight (5.24%) 4th day after harvest when trees were treated with 75% NPK + vermicompost 15 kg + AAU Bio NPK 10 ml/tree.

Pomegranate

Hiwale (2009) [16] mentioned about an experiment carried out at Central Horticultural Experiment Station, Vejalpur on pomegranate crop and reported that fruit characteristics of pomegranate like fruit weight (188.75 g), fruit length (69.72 mm), fruit retention per plant (57) and fruit yield (10.75 kg/plant) were significantly observed maximum when plants treated with 50 per cent N through FYM + 25 per cent N through castor cake + 25 percent N through urea. Dighe *et al.* (2014) [7] reported that total number of fruits per tree (86.27), marketable fruit yield (27.95 kg/tree or 20.68 ton/ ha) and total fruit yield (31.06 kg/tree or 22.98 ton/ha) were found significantly maximum when pomegranate plants treated with GRDF while average weight of fruit (370 g) were found significantly maximum in 50% RDN and 50% N through FYM treatment. Dutta Ray *et al.* (2014) [8] investigated that the fruits of pomegranate treated with 300 g nitrogen + 1 kg neem cake plant per hectare showed significantly maximum fruit weight (239.83 g), fruit length (7.75 cm), fruit yield (6.94 kg/plant), juice content (75.63%), total soluble solid (12.29 ^{0}Brix), TSS/acid ratio (31.36), reducing sugar (9.78%) and total sugar (10.74%) with minimum acidity (0.39%). Greeshma *et al.* (2017) [14] carried out an experiment on pomegranate crop at Kaladagi village of Bagalkot district, Karnataka and recorded the highest number of hermaphrodite flowers (139.0), number of fruit (98.01) and marketable fruit yield (26.43 kg/plant & 19.56 t/ha) with application of 50% RDN & P_2O_5 (200: 100: 200 N:P_2O_5:K_2O gram per plant) + 20 kg oil cakes + bioinoculants treatment. Whereas, fruit weight (294.20 g) and size (77.19 & 102.55 mm fruit diameter and length) was noticed maximum in 75% RDN & P_2O_5 (300: 150: 200 N: P_2O_5 : K_2O gram per plant) + 10 kg oil cakes + bioinoculants treatment. Kirankumar *et al.* (2018) [17] conducted an experiment on pomegranate at the farmer's field of Somerhalli village, Hiriyurtaluk of Chitradurga district, Karnataka and revealed that application of 100% recommended dose of fertilizers (RDF) along with vermicompost + poultry manure + *Azospirillum* + PSB + KSB has recorded the maximum aril weight (212.47 g), aril per cent (72.53%) and lowest seed: aril ratio (0.016). Whereas, maximum TSS (15.30 ºBrix), TSS/TA ratio (46.48%), reducing sugars (12.79%), non-reducing sugars (1.65%) total sugars (14.39%), and lowest titratable acidity (0.33%) was recorded in 100% recommended dose of fertilizers (RDF) along with vermicompost + poultry manure + *Azospirillum* + PSB + KSB.

Papaya

Singh *et al.* (2010) [37] revealed that maximum number of leaves (18.73), trunk girth (0.26 m), number of fruits per plant (46), average fruit weight (0.85 kg), pulp thickness (3.5 cm), shelf life of fruit (12 days), vitamin A (2280 IU/100 g pulp) and TSS (15.8 °Brix) were recorded with 75% RDF + 25% vermicompost + rhizosphere bacteria culture treatment, while maximum plant height (185.35 cm) and petiole length (8.42 cm) were observed with 100% RDF alone. Yadav *et al.* (2011) [46, 47] revealed that combination of 10 kg vermicompost + 100% NPK+ 25 g *Azotobactor* enhanced the growth characters like plant height, girth and fruiting depth and improved physico-chemical characters like fruit length, width, ascorbic acid, total soluble solids and total sugar content compared to other treatments. Shivakumar *et al.* (2012) [35] revealed that application of FYM equivalent to 100 per cent recommended dose of nitrogen (RDN) (154.3 t/ha) in papaya gave significantly higher fruit yield of 173.9 t/ha as compared to control with RDF and other organic manure treatments except agrogold equivalent to 100 per cent RDN (33.32 t/ha) and vermicompost, sheep manure and bhumilabha in combination with FYM treatments each equivalent to 50 per cent RDN. Tandel *et al*. (2017) [41] indicated that the application of 25% RDN through biocompost + 25% RDN through castor cake + 50% RDN through inorganic fertilizer gave higher values of yield characters *viz*., number of fruit (28.57), average weight of fruit (1.062 kg), yield per plant (30.24 kg), yield per hectare (83.99 t), fruit diameter (24.87 cm) and fruit volume (900.23 ml) with minimum fruit cavity index (24.13%) and initiation of flowering (105.17 day). Similarly, fruit firmness (7.38 Kg/cm^2), shelf life (7.54 days), total soluble solid (8.12%), total sugar (9.80%), reducing sugar (8.45%) and vitamin C (23.90 mg/100g pulp) was found in same treatment along with minimum physiological loss in weight (11.20%) and titrable acidity (0.016%).

Bael

Vishwakarma *et al.* (2017) [45] showed that maximum fruit length, fruit width, fruit weight, pulp weight, TSS and ascorbic acid were recorded with application of 50 kg FYM + 100% NPK + 200 g each (*Azotobacter* + PSB).

Ber

Bohane and Tiwari (2014) [4] conducted an experiment at College of Horticulture, Mandsaur on five years old trees of ber cv. Gola and revealed that the application of 50 per cent recommended dose of NPK as vermicompost + 50 per cent RDF NPK + 50 g *Azotobacter* + 50 g PSB significantly increased the fruit length and diameter, fruit volume, pulp weight, stone weight, TSS, ascorbic acid, reducing sugar, non-reducing sugar, total sugars, TSS/acid ratio and chlorophyll content in leaves spad value over other treatments.

Litchi

Dutta *et. al.* (2010) [9] shown that the application of 50 kg/tree FYM + 150 g *Azotobacter* + 100 g VAM + 500 g N: 250 g P_2O_5: 500 g K_2O/tree/year through fertilizer showed maximum yield (98.72 kg/plant) and also have a significant improvement in terms of TSS, total sugars, ascorbic acid, TSS: acid ratio, fruit weight and fruit size. Rani *et al*. (2013) [33] conducted an experiment on litchi cv. Rose Scented for two years at Horticulture Research Centre, Patharchatta, Pantnagar and obtained maximum tree height, tree spread, tree volume, panicle length, fruit set, fruit retention and higher yield through application of FYM at 150 kg per tree.

Aonla

Korwar *et al.* (2006) [18] stated that the growth, yield and quality of aonla were influenced by different sources of nutrients. Combination of organics and inorganic nutrients increased the fruit yield and quality. Application of vermicompost improved the fruit quality. Mandal *et al*. (2013) [24] concluded that the application of 100: 25:150 g NPK/plant + 10 kg FYM + 50 g PSB /plant is beneficial for increasing vegetative growth as well as improving yield and yield attributing characters of aonla cv. NA-7 under red and lateritic region of West Bengal.

Phalsa

Verma *et al.* (2014) [44] revealed that the application of FYM + 75 per cent NPK + *Azotobacter* + PSB + $ZnSO_4$ (0.4%) recorded maximum plant growth and fruit yield (5.06 kg per plant and 5.23 kg per plant) in both the year, respectively. Similarly, maximum physical characters *viz.*, fruit length (1.13 and 1.15 cm), fruit breadth (1.37 and 1.35 cm), weight of fifty fruits (38.63 and 39.10 g) and juice per cent (51.11 and 51.92%) and pulp/stone ratio (1.60 and 1.62) as well as maximum chemical characters *viz.*, TSS (27.64 and 27.91%), ascorbic acid (38.51 and 38.21 mg/100 ml juice), reducing sugars (19.38 and 19.40%), non reducing sugars (2.37 and 2.38%) and total sugars (21.74 and 21.78%) along with minimum acidity (2.24 and 2.20%) were obtained in the same treatment during both the years respectively. Mani *et al.* (2013) [25] studied that application of *Azotobacter* inoculated treatment with 75% N substitution by phosphate solubilizing bacteria and remaining 25% through inorganic fertilizer in two equal splits at establishment and before flowering stage increased length of shoot, number of shoot, number of leaves per shoot, internodal lengths, number of fruit per node, number of fruiting node per shoot, fruit yield, fruit length & width, juice per cent, pulp stone ratio and acidity. Basith *et al.* (2018) [2] concluded that pruning of phalsa bushes around 20th December has resulted in more number of fruit clusters and yield under the Southern Telengana Agro-climatic conditions. Integrated application of 50% RDF along with organic manure and biofertilizers is best option to obtain higher yields and superior fruit quality in phalsa.

Conclusion

It may be concluded that application of biofertilizers and organic manure along with recommended dose of fertilizers improved the plant growth, yield and quality parameters in fruit crops. It also increases fertilizer use efficiency, ecological safety and maintain soil health on long term basis.

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